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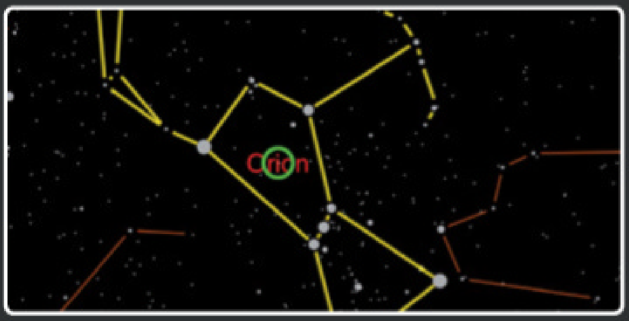

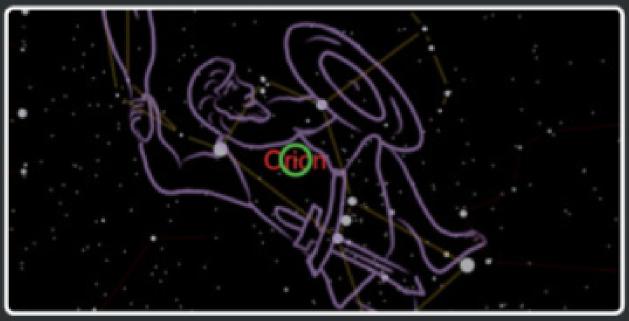

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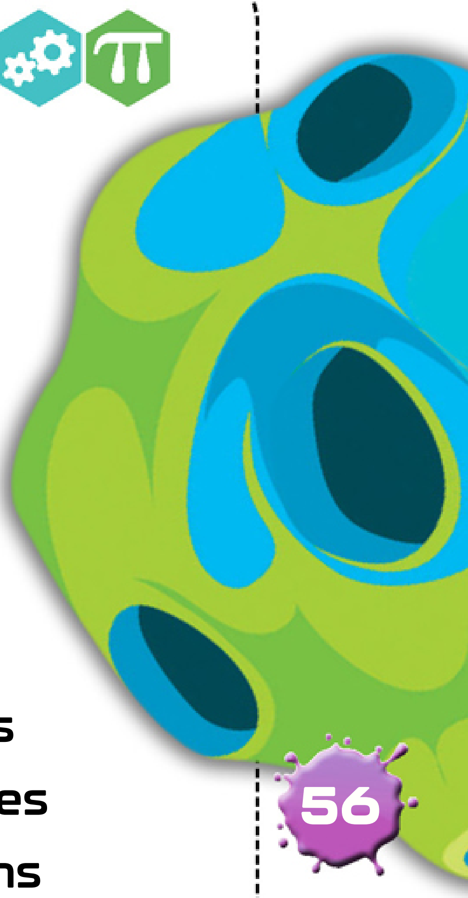

LOOK FOR THESE FUN GUYS WITH THE JOKES!

Hi, kids!

Everyone loves astronomy projects. In a workshop at the 2014 Starlight Astronomy Festival, kids made models of Saturn out of Styrofoam balls and CDs. Then they decorated them with beads, glitter, and more. Fun! MICHAEL E. BAKICH

Also, a big "hello" to all you parents and teachers. Thanks for supporting *Astronomy for Kids*.

The staff of *Astronomy* has been involved in science education ever since the magazine started in 1973, but our stories have been mainly for adults. *Astronomy for Kids* is the first publication we've produced specifically for kids. And, to be honest, we had a blast putting it together!

And when I say "we," I'm really giving the credit to Kelly Katlaps, the graphic designer for every story in this magazine. Her creations are colorful and enticing — exactly what was needed. Kelly is awesome!

Astronomy for Kids has something for everyone. Maybe your children like being out under the stars. Or maybe they enjoy indoor activities more. You'll find plenty in here to keep both types interested.

Of course, we had to pick an order for the stories, but it's OK if you want to jump around. If "Sizing up the Moon" seems like something your kids would enjoy, head for p. 48 and start there. You don't have to read or do any of these activities on a specific date. Well, except for the ones about the stars and constellations in the four seasons — and you have three months to do each one of those.

If you bought this magazine in May, your kids should start their tour of the stars with "Meet the stars of spring" on p. 20 because those are the stars overhead in the real sky after the Sun goes down. If it's October, "Meet the stars of fall" on p. 52 would work better. And so on.

One feature we know kids will enjoy is the 12-part comic, *Outer Space Pals*. It's so colorful and fun to look at. And to increase its educational value, we created a guide for it, starting on p. 94. So, if there's something in one of the comics your children don't understand, head to that guide to learn more about it.

Looking to the future, we're planning to do more kid-related projects like this one. So, I'm asking for your help: Tell me what you think about *Astronomy for Kids*. What do your children or students like about it? What don't they like? What should we do more of? Less? What subjects would you like us to cover in future magazines like this one? Please let me know if you're a parent or a teacher. (And, if so, what grade[s] do you teach?)

I would appreciate it so much if you'd take a minute or two to send me your thoughts. You can reach me by email at kids@astronomy.com. Now gather up your kids and go do some astronomy!

Sincerely,

Michael E Bakich

ASTRONOMY for KIDS

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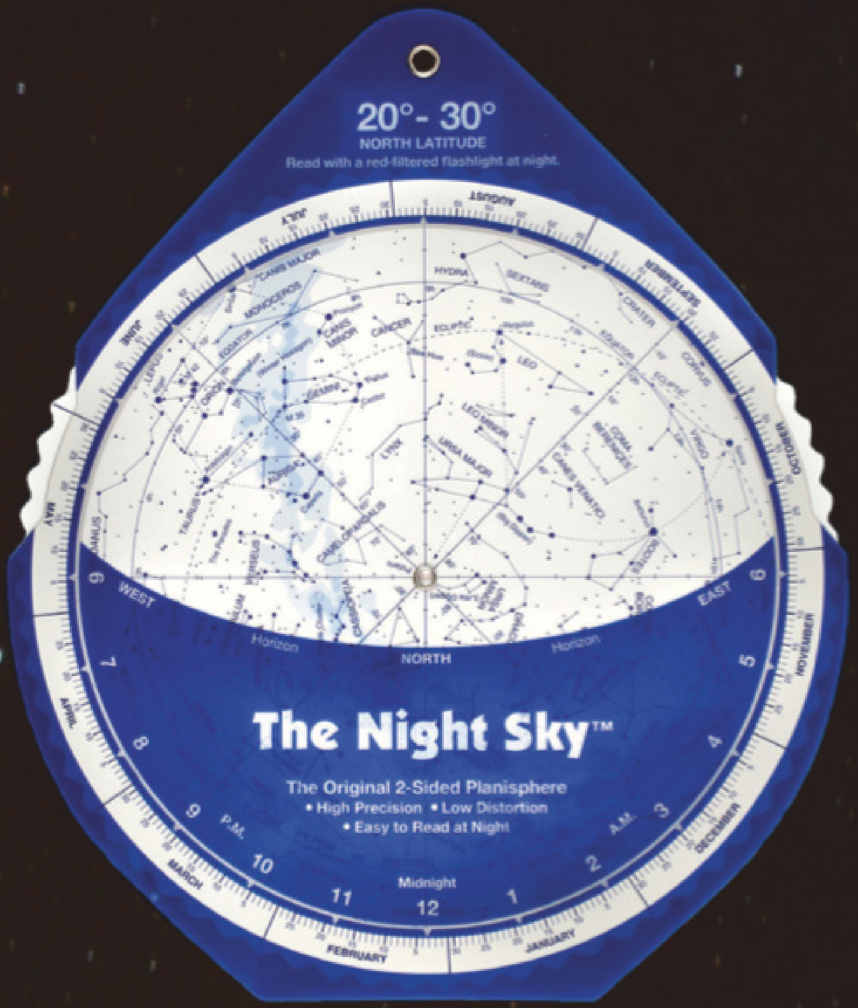
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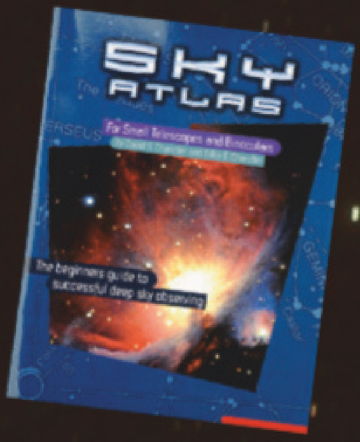
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Astro Q&A

1 WHO INVENTED THE TELESCOPE?

Dutch eyeglass-maker Hans Lipperhey invented it in 1608. Italian astronomer Galileo Galilei is more famous for using his telescopes. His discoveries included craters on the Moon, sunspots, and stars fainter than the eye could see.

2 HOW DOES THE SUN MAKE ENERGY?

In the Sun's center, high temperature and pressure make hydrogen atoms move fast, and there are so many of them that they hit each other — a lot. When four of them stick together, they make helium. The change from hydrogen into helium — called nuclear fusion — makes energy.

3 HOW MUCH OF THE SUN'S ENERGY DOES EARTH GET?

Only one part in 2 billion. In other words, the Sun gives off 2 billion times as much energy as our whole planet receives.

4 WHY DOES THE MOON RISE LATER EACH NIGHT?

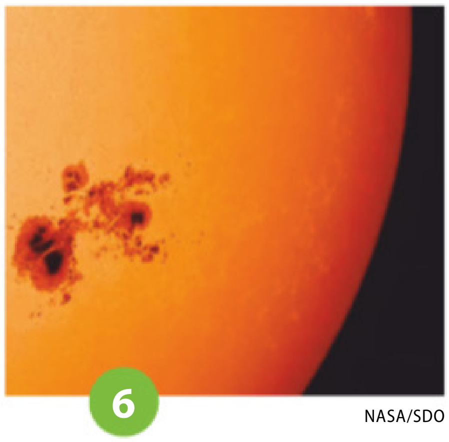
The Moon moves west to east through the sky, so on any night, it's about 12° east of where it was the night before. Because it moves, it rises about 50 minutes later each night.

5 HOW ARE STARS AND PLANETS DIFFERENT?

Stars make their own light and heat the same way that the Sun does (see question 2). Planets don't make their own light, but they reflect light from any star near them. The planets in our solar system reflect the Sun's light. Planets also are much smaller and weigh a lot less than any of the stars.

6 WHY ARE SUNSPOTS DARK?

Actually, they're not dark. They're really bright. They just look dark because they are about 3,000 degrees Fahrenheit cooler than the surface of the Sun near them. That makes their temperature about 8,000 F. So, if you could see them by themselves, they would shine brightly.



NASA/SDO

7 WHO DISCOVERED JUPITER'S FOUR LARGE MOONS?

Galileo did. He found three of them (Io, Europa, and Callisto) January 7, 1610. On January 13, he discovered the fourth one, Ganymede. He first thought they were stars, but he watched them for several weeks and saw that they moved around the planet.

8 WHAT ARE THE MAIN TYPES OF METEORITES?

About 94 percent are stone meteorites. Iron meteorites (made of iron and nickel) are about 5 percent, and stony-iron meteorites are just 1 percent.

9 WHAT MADE SATURN'S RINGS?

Long ago, one of Saturn's moons got so close to the planet that Saturn's gravity tore it into trillions of particles, forming the rings.

10 HOW DID THE SOLAR SYSTEM FORM?

Gravity brought atoms of gas and dust together into clumps that got bigger and eventually made the Sun, planets, moons, asteroids, and comets.

11 WHEN DID ASTRONOMERS CHOOSE THE CURRENT CONSTELLATIONS?

In 1928. Before then, sky mapmakers could put as many star patterns on their star charts as they wanted. Now, 88 constellations cover the sky. Only one — Serpens — has two parts.

12 WHY DO STARS TWINKLE?

A star gives off a steady light. But we see it twinkling because of Earth's atmosphere. Each star is just one point of light. When it passes through air (on its way to our eyes), layers of air bend the light up and down and left and right, so the star seems to twinkle. And sometimes when we watch a bright star, we can see different colors because the layers of air break up the star's light.

13 WHAT IS DARK ADAPTION?

It's how we see at night. Our eyes get more sensitive (adapt to the dark) the longer we're outside away from bright lights. And here's a cool fact: In the first 30 minutes, our eyes' sensitivity increases 10,000 times.

14 WHY DO SOME STARS CHANGE BRIGHTNESS?

The most common reason is that we're looking at a double star where one passes in front of the other, hiding it from us and dimming its light. Some stars grow and shrink, and as they do their brightness changes. Other stars have eruptions, which makes them bright for a short time. Recently, astronomers have found the brightnesses of more than 1,500 stars drop ever so slightly because planets are crossing in front of them from our point of view.

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15 HOW DO ASTRONOMERS STUDY STARLIGHT?

They use special equipment to break the light into a spectrum, which looks like a rainbow. A spectrum is a graph that shows the strengths of each of the colors. By comparing a star's spectrum to one made in a laboratory, astronomers can figure out what elements are in the star.

16 WHAT IS LIGHT POLLUTION?

It's any kind of lighting that makes it harder for people who want to watch the sky. The closer you are to a city (especially a big one), the worse it is. Light pollution, in addition to hurting astronomy, disturbs animals, affects human behavior, and wastes $2.2 billion per year.

NASA/JPL

17 WHY IS MARS CALLED THE RED PLANET?

The color comes from the large amount of iron oxide — known on Earth as rust — on the planet's surface. So, we could also call Mars the Rusty Planet!

18 HOW MANY STARS ARE IN THE MILKY WAY?

Astronomers think our galaxy has between 250 billion and 400 billion stars. This number isn't exact because we don't know how many really faint stars are in it. They're hard to find, especially if they're far away.

19 WHAT CREATES THE GLOW OF THE MILKY WAY?

This faint glow that you can see from a dark site is the combined light of billions of stars along our galaxy's plane. They're too far for our eyes to see them as points like the closer stars, so their light combines to create a pretty glow.

20 HOW MANY STARS CAN YOU SEE FROM A DARK SITE?

Most adults could spot about 5,000 stars if they watched the sky the whole night. Kids, whose eyes are more sensitive, can count 8,000.

JOHN VERMETTE

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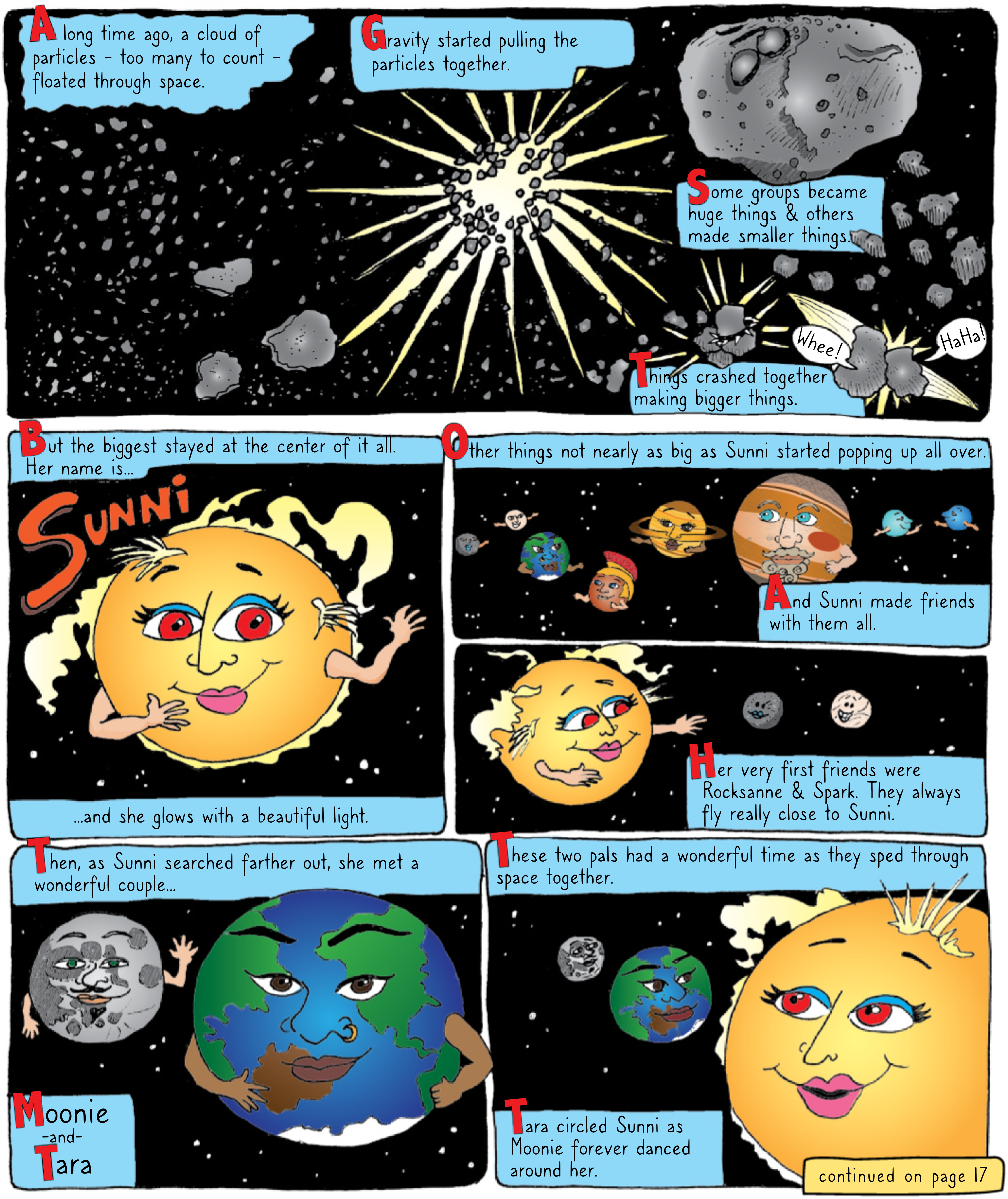
OUTER SPACE Pals

art, color, & lettering by Holley Bakich


A long time ago, a cloud of particles – too many to count – floated through space.
Gravity started pulling the particles together.
Some groups became huge things & others made smaller things.
Whee!
HaHa!
Things crashed together making bigger things.
But the biggest stayed at the center of it all. Her name is...
SUNNI
...and she glows with a beautiful light.
Other things not nearly as big as Sunni started popping up all over.
And Sunni made friends with them all.
Her very first friends were Rocksanne & Spark. They always fly really close to Sunni.
Then, as Sunni searched farther out, she met a wonderful couple...
Moonie
-and-
Tara
These two pals had a wonderful time as they sped through space together.
Tara circled Sunni as Moonie forever danced around her.

continued on page 17

Look at the MOON!

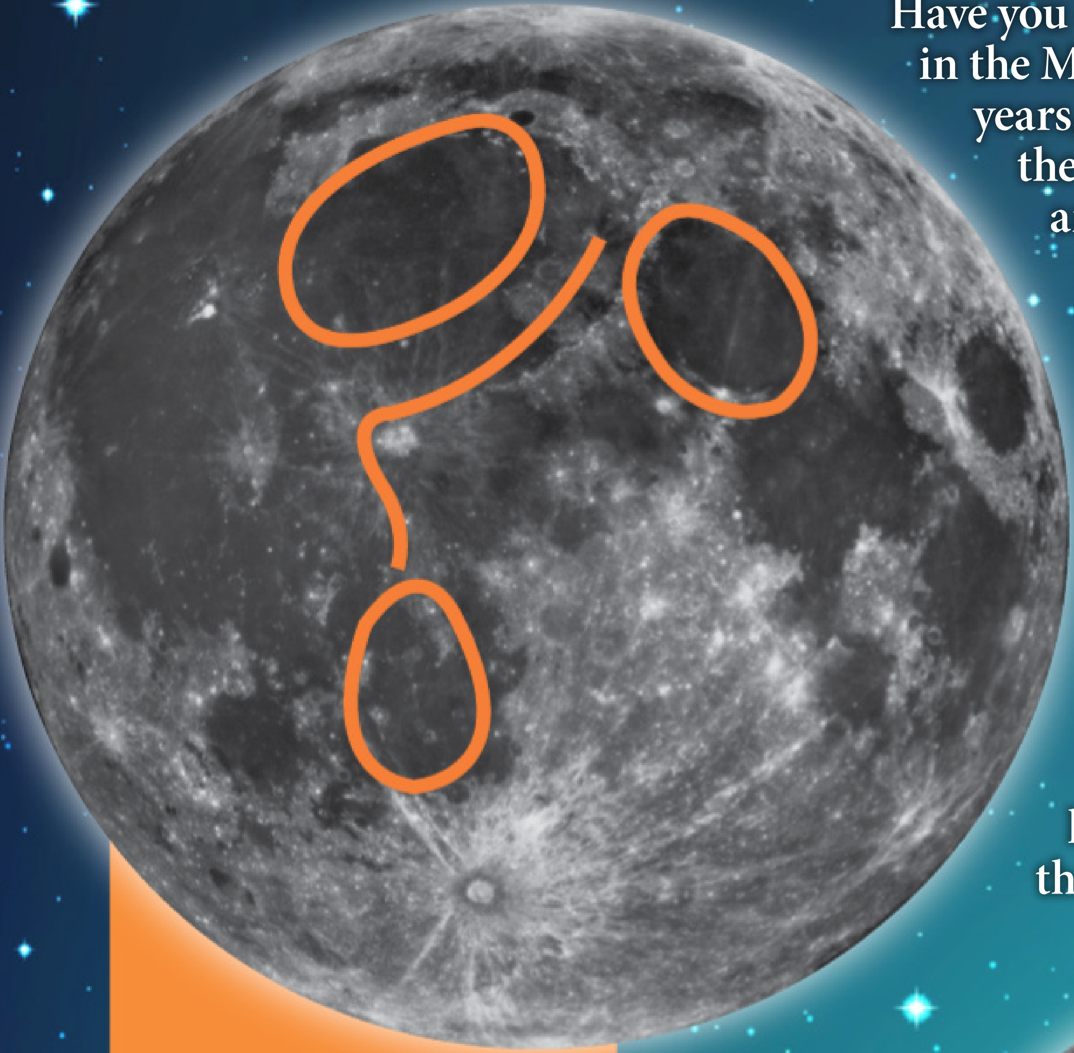
by Michael E. Bakich

Have you ever heard about the Man in the Moon? For thousands of years, people have looked at the Moon and seen faces, animals, and lots of other things. We imagine different things on the Moon's surface because it's not a single color. Instead, there are light areas and dark areas.

Because we've studied the Moon through telescopes for a long time — and especially because astronauts have visited it — we know that the light parts of the Moon are mountain ranges. They're just like the ones we have on Earth. Scientists call them the highlands.

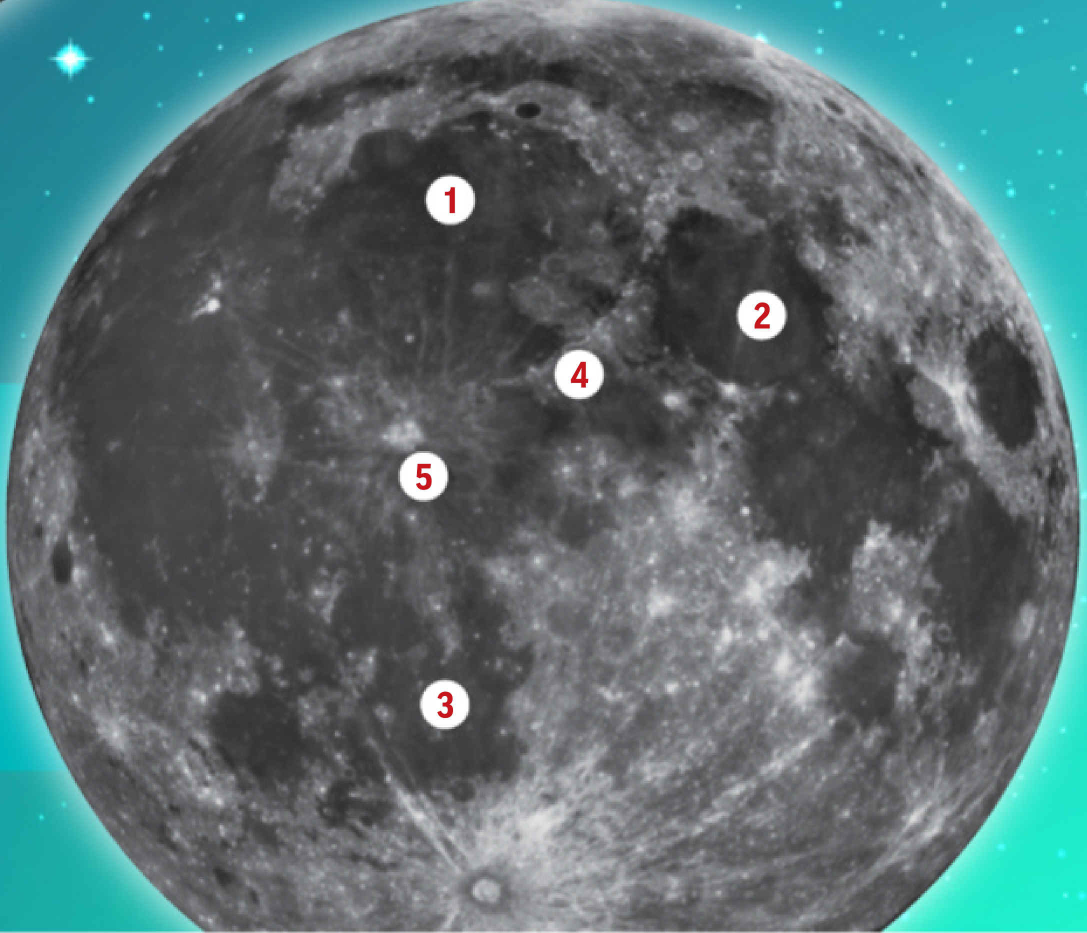
FUN FACT

If you weigh 100 pounds (45.5 kg) on Earth, you'd weigh only 16.5 pounds (7.5 kg) on the Moon.



When the Moon is Full, here's how to make the Man in the Moon.

ALL MOON IMAGES: LUNAR AND PLANETARY INSTITUTE



Here are the real names of the features making up the Man in the Moon: 1. Mare Imbrium (Sea of Rains); 2. Mare Serenitatis (Sea of Serenity); 3. Mare Nubium (Sea of Clouds); 4. Apennine Mountains; 5. Copernicus Crater.

The large dark areas of the Moon are its seas. But these seas are very different from the oceans on our planet. Here, we have liquid water. There's none of that on the Moon. Long ago, however, people imagined that those dark areas contained water, and that's how they got their name. Actually, people called them *maria*, the Latin word for "seas." (If you're talking about just one sea, the word is *mare*.)

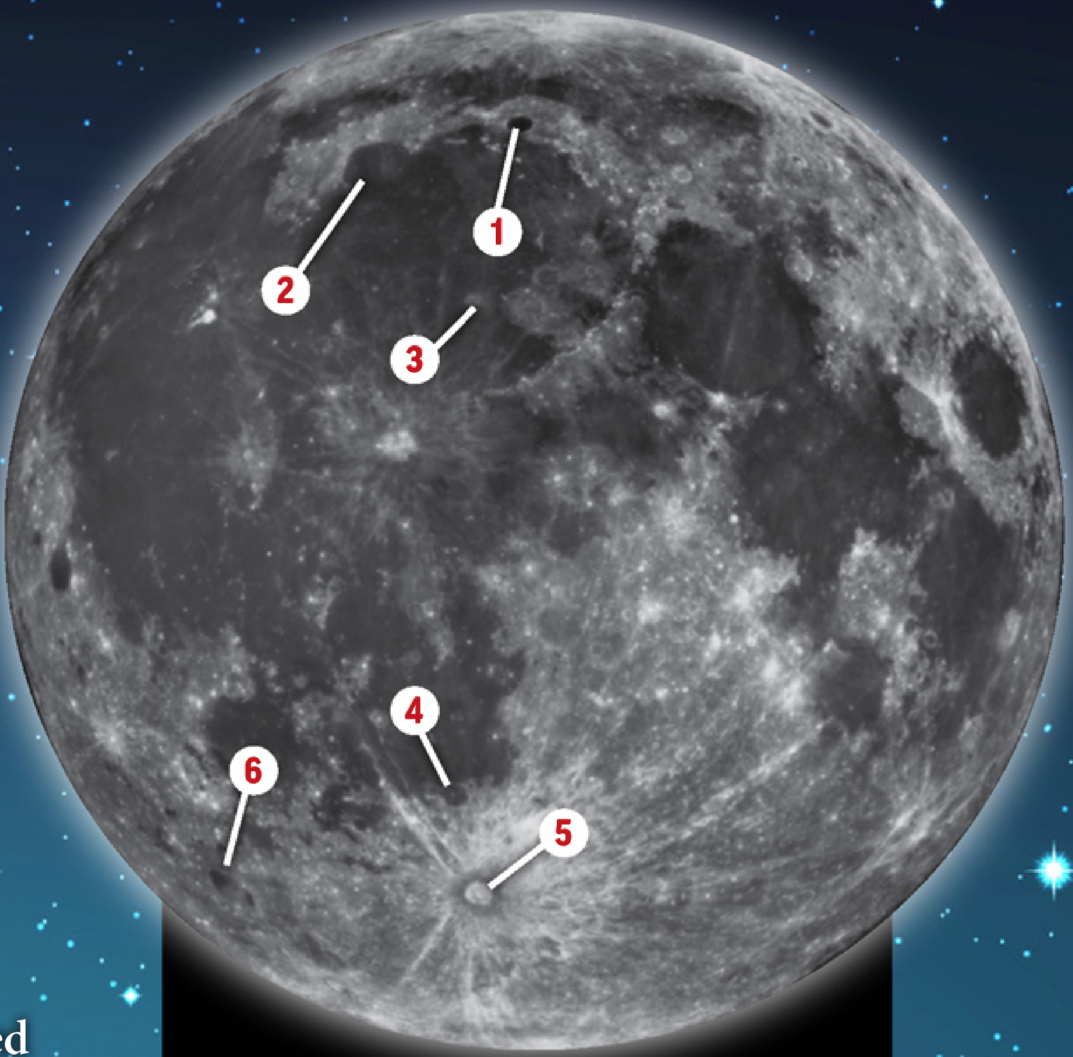
The maria formed about 3.5 billion years ago, when dark lava flowed over those parts of the Moon. Most of the brighter areas are the highlands that the lava didn't reach. Inside the maria, you can see bright craters. Those formed when rocks from space, called meteors, slammed into the lava, blasting away the darker stuff.

Some of these bright and dark patches happen to form a pattern that we recognize as a face. Mare Imbrium and Mare Serenitatis form the Man in the Moon's eyes. Mare Nubium is his mouth. And his nose is formed by the bright Apennine Mountains along with Copernicus Crater.

With a little imagination, you can see a lot more than just the Man in the Moon. Some people see a woman; others see a dog; still others see a rabbit, a toad, and more. What do you see?

FUN FACT

When the Moon is half-full (First and Last Quarter phases), it's only 10% as bright as the Full Moon.



Here are six more things to look for when the Moon is Full: 1. Plato Crater; 2. Sinus Iridum (Bay of Rainbows); 3. Archimedes Crater; 4. Pitatus Crater; 5. Tycho Crater; 6. Schiller Crater.

WHAT ELSE CAN YOU SEE?

There are so many cool things to see on the Moon. And what's great is that you can view them from anywhere. The Moon is so bright that even city lights won't stop you from looking at it.

You can see some things on the Moon's face with just your eyes. Binoculars will let you see more. And through a telescope, you can see thousands of craters, seas, and mountains. If you don't have a telescope, find out if there's an astronomy club in your area. If so, have your parents give them a call to see when they will be showing the Moon to people. (You'll probably see lots more cool stuff that evening, too.)

The next clear night that the Moon is out, try to find the six features that we show on this map.

Q: Which keyboard key do astronauts use the most?

A: The space bar!

ASTRONAUT: DANIELFELA/DREAMSTIME

EXPLORE OUR SOLAR

by Michael E. Bakich

Earth is a planet in our solar system, which we can think of as the Sun's family. The solar system formed 4½ billion years ago. Before that, gravity made a huge cloud of gas and dust smaller. As time went on, most of the stuff got pulled into the center. That made the Sun. But other parts of the cloud got smaller and turned into round objects, too. That's how the planets and their moons formed. Let's take a little time to meet the most important members of the solar system. ALL PLANET IMAGES: NASA

Q: What did Venus say to Saturn?
A: Give me a ring sometime!

The Sun

"THE SUN IS A MASS of incandescent gas, a gigantic nuclear furnace." This line from the song "Why Does the Sun Shine?" by They Might Be Giants is right: Gas is what our Sun is made of.

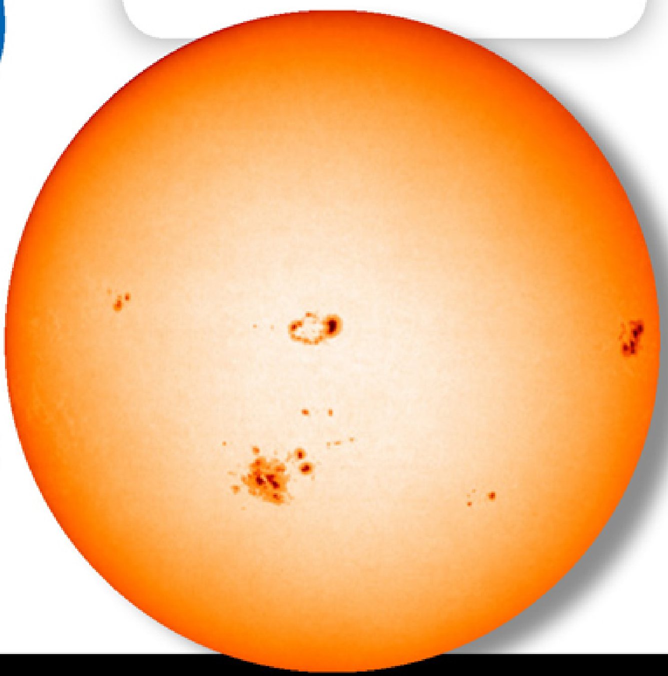
The second part of the line from that song also is true. The center of the Sun is at such a high temperature that it changes hydrogen into helium in what scientists call a nuclear reaction. Did you know that for the Sun to shine, it must change 4 million tons of hydrogen into helium *each second*? Wow!

Our Sun is a star. It's just like all the stars we see at night. The main difference between the Sun and the stars is distance — even the next nearest star is more than 250,000 times farther away than the Sun. Because they are so far away, all we see of any other star is a point of light. But because the Sun is so close, we see its face as a circle, or disk.

SUN FACTS

Mass: 4.384 million trillion trillion pounds
Diameter: 864,949 miles
Surface temperature: 11,000° F
Length of day (equator): 25.4 days
Length of day (45° latitude): 27.3 days

SUN



MERCURY

Mercury

MERCURY IS THE SMALLEST planet and the one closest to the Sun. It also has no air. On Earth, air carries some daytime heat into the night. But Mercury doesn't have air to raise its night temperature. So, when the Sun shines anywhere on the planet, the temperature there is 1,000 degrees hotter than when it's night at the same spot.

Mercury's orbit is the most stretched-out of any planet. Its distance when it's farthest from the Sun is 43,400,000 miles (69,800,000 kilometers). But when it's closest to the Sun, that distance drops to 28,600,000 miles (46,000,000 km). That's a big difference! Mercury looks like our Moon because it has craters all over its surface.

The Sun has changed Mercury's orbit a lot. It spins three times for every two of its trips around the Sun. In other words, Mercury has only three days every two years.

MERCURY FACTS

Mass: 0.7280 trillion trillion pounds (5.5% of Earth's)
Diameter: 3,032 miles (38.3% of Earth's)
Distance from Sun: 35.98 million miles (38.7% of Earth's)
Length of year: 87.969 days (24.1% of Earth's)
Length of day: 4,223 hours (176 times Earth's)

ASTRONAUT: DANIELFELA/DREAMSTIME

SYSTEM

EARTH

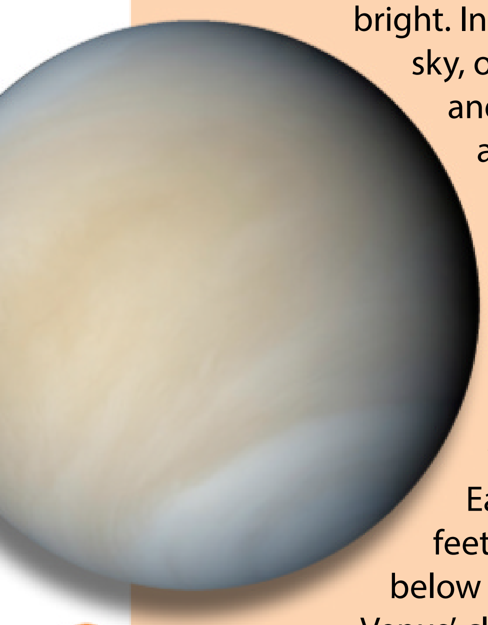
Venus

THE SECOND PLANET out from the Sun is Venus. Venus is sometimes called "Earth's twin" because its size is closest to Earth. Venus' diameter is only 397 miles (639 km) less than Earth's.

Venus has a strange day. It's 18 Earth days longer than Venus' year, and when astronomers study the planet, it seems to spin in the opposite direction of most other planets.

We never see Venus' surface because a thick layer of clouds covers it. The clouds reflect lots of sunlight, and that makes Venus really bright. In fact, in our sky, only the Sun and the Moon are brighter. The clouds make the atmospheric pressure on Venus the same as if you were on Earth, but 3,000 feet (914 meters) below sea level.

Venus' clouds trap a lot of the Sun's heat. That makes its temperature the hottest in the solar system: 863 degrees Fahrenheit (462 degrees Celsius). Yep, Venus wouldn't be a nice place to visit.



VENUS

VENUS FACTS

Mass: 10.73 trillion trillion pounds (81.5% of Earth's)
Diameter: 7,521 miles (95.1% of Earth's)
Distance from Sun: 67.24 million miles (72.3% of Earth's)
Length of year: 224.70 days (61.5% of Earth's)
Length of day: 2,802 hours (117 times Earth's)

The Moon

THE MOON IS THE FIRST natural satellite we meet as we travel out from the Sun. Here's something interesting: The Moon orbits Earth in 27.3 days. But because Earth orbits the Sun, it takes longer for the Moon to go through its phases. In fact, it takes 29½ days for it to go from Full Moon to the next Full Moon, or First Quarter to the next First Quarter (that's when it's half-full), or any phase to the next same phase.

From 1969 to 1972, six pairs of astronauts landed on and explored the Moon's surface. They brought back more than 840 pounds (380 kilograms) of Moon rocks for scientists to study.

MOON FACTS

Mass: 0.1620 trillion trillion pounds (1.23% of Earth's)
Diameter: 2,160 miles (27.3% of Earth's)
Distance from Earth: 239,000 miles
Orbital period: 27.322 days
Length of day: 708.7 hours (29.5 times Earth's)

MOON

Earth

EARTH IS THE THIRD planet from the Sun. Earth is special because it's the only planet with liquid water on its surface and the only place in the universe where we know life exists. Water covers 71 percent of the surface, and ice covers another 10 percent.

Earth spins on an axis that's tilted almost 23½ degrees. You'll read more about that and how it makes our seasons on p. 18. Our planet reflects back into space nearly 37 percent of the sunlight that hits it.

Two main gases make up Earth's atmosphere: Nitrogen is 78 percent of it, and oxygen is 21 percent. All the other gases, like water vapor and carbon dioxide, make up the last 1 percent.

EARTH FACTS

Mass: 13.17 trillion trillion pounds
Diameter: 7,926 miles
Distance from Sun: 92.96 million miles
Length of year: 365.24 days
Length of day: 24 hours

Mars

MARS IS THE FOURTH PLANET from the Sun, and it's sometimes called the Red Planet. That's a good name because Mars is covered by the stuff that creates rust on Earth.

Mars has a thin atmosphere, but it's almost all carbon dioxide — the gas that we breathe out. Mars has a lot of things in common with Earth: mountains, hills, volcanoes, ridges, plains, craters, and ice caps at the poles.

The two ice caps of Mars are made mainly of water ice with some frozen carbon dioxide, sometimes called dry ice. When it's winter in Mars' northern half, that ice cap gets a layer of dry ice about 3 feet (1 m) deep. The southern ice cap is also mainly water ice, but it has a permanent dry ice cover about 25 feet (8 m) thick.

MARS FACTS

Mass: 1.415 trillion trillion pounds (10.7% of Earth's)
Diameter: 4,221 miles (53.2% of Earth's)
Distance from Sun: 141.6 million miles (1.524 times Earth's)
Length of year: 686.98 days (1.881 times Earth's)
Length of day: 24.66 hours (1.027 times Earth's)

Jupiter

JUPITER IS THE FIFTH PLANET out from the Sun and the biggest planet by far. It has two and a half times the mass of all the other planets combined, but it would still take 1,000 Jupiters to equal what's in the Sun. Jupiter is the first of the gas giant planets. About three-quarters of the planet is hydrogen, and one-quarter is helium. It may have a small, rocky core deep inside.

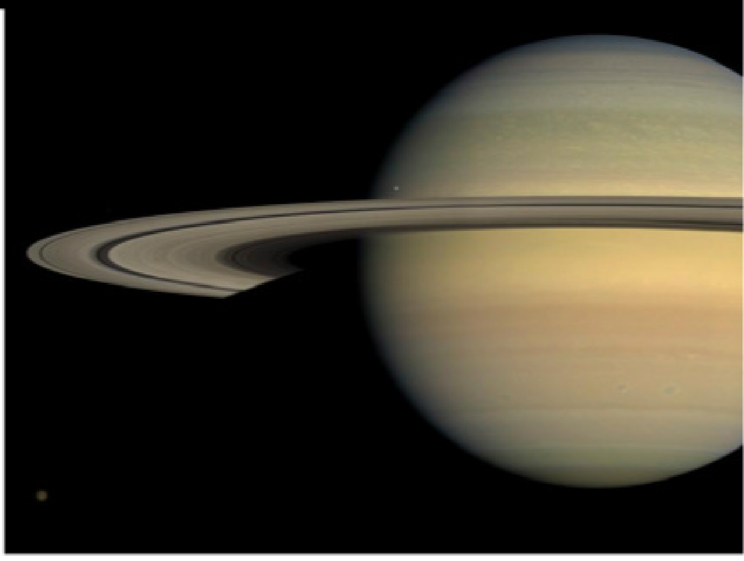
Do you think our planet is big? It sure looks big. But Jupiter is huge! If it were hollow, 1,321 Earths would fit inside. Amazingly, even as large as it is, Jupiter spins faster than any other planet. Its day is only 9 hours, 55 minutes, 30 seconds long.

Through even a small telescope, we can see Jupiter's four biggest moons: Ganymede, Callisto, Europa, and Io. The Italian astronomer Galileo Galilei discovered them in 1610 with one of his first telescopes.

Because Jupiter's clouds are so thick, all we can see of the planet is the top of its atmosphere. It divides into belts and bands with different colors, and it also features the Great Red Spot, a giant storm that's at least 300 years old.

JUPITER FACTS

Mass: 4,186 trillion trillion pounds (318 times Earth's)
Diameter: 88,864 miles (11 times Earth's)
Distance from Sun: 483.8 million miles (5.2 times Earth's)
Length of year: 11.86 years (11.9 times Earth's)
Length of day: 9.926 hours (41.4% of Earth's)



Saturn

THE SIXTH PLANET IN OUR solar system is beautiful Saturn. Here, you'd be almost 30 years old before you celebrated your first birthday. Like Jupiter, Saturn is mostly hydrogen and helium.

At least 62 moons orbit Saturn. The largest, Titan, is bigger than the planet Mercury and is the only moon with a large atmosphere. The spacecraft that orbited Saturn, called Cassini-Huygens, discovered lakes of liquid ethane and methane on Titan.

In most people's minds, what makes Saturn special are its spectacular rings. They begin less than 4,000 miles (6,400 km) from the planet and go out to 75,000 miles (120,700 km). They're really thin, though — they average only 65 feet (20 m) thick.

The rings are made of trillions of individual particles. Most are the size of dust specks, but a few are as large as 33 feet (10 m) across. Their composition is 93 percent water ice and 7 percent carbon (like the lead in a pencil). The gravity of a few of Saturn's tiny moons keeps the rings in place.

SATURN FACTS

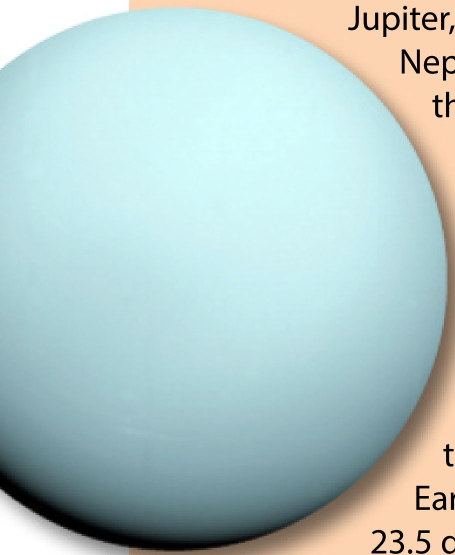
Mass: 1.253 trillion trillion pounds (95 times Earth's)
Diameter: 74,898 miles (9.5 times Earth's)
Distance from Sun: 890.8 million miles (9.6 times Earth's)
Length of year: 29.457 years (29.5 times Earth's)
Length of day: 10.6 hours (44% of Earth's)

SATURN

Uranus

A VOYAGE TO THE SEVENTH planet leads us to Uranus. Uranus' atmosphere — and Neptune's — has a lot of hydrogen and helium, so they're like Jupiter and Saturn. The two outer planets, however, contain more of other gases such as water vapor, ammonia, and methane.

When astronomers point their telescopes toward Uranus, they don't see a lot of details. That makes it different from Jupiter, Saturn, and Neptune. Those three planets show us lots of patterns in their clouds. Probably the most unusual thing about Uranus is the tilt of its axis. Earth's axis tips 23.5 degrees. But the axis of Uranus tilts almost 98 degrees! This gives it seasons unlike any of the other planets. Each of its poles gets sunlight for about 42 years, then they're dark for the next 42 years. When you think of how Uranus moves around the Sun, picture a ball rolling rather than a top spinning, which is how the other planets appear to move.



URANUS

URANUS FACTS

Mass: 191.4 trillion trillion pounds (14.54 times Earth's)
Diameter: 31,763 miles (4 times Earth's)
Distance from Sun: 1,785 million miles (19.2 times Earth's)
Length of year: 84.01 years (84 times Earth's)
Length of day: 17.24 hours (71.8% of Earth's)

Neptune

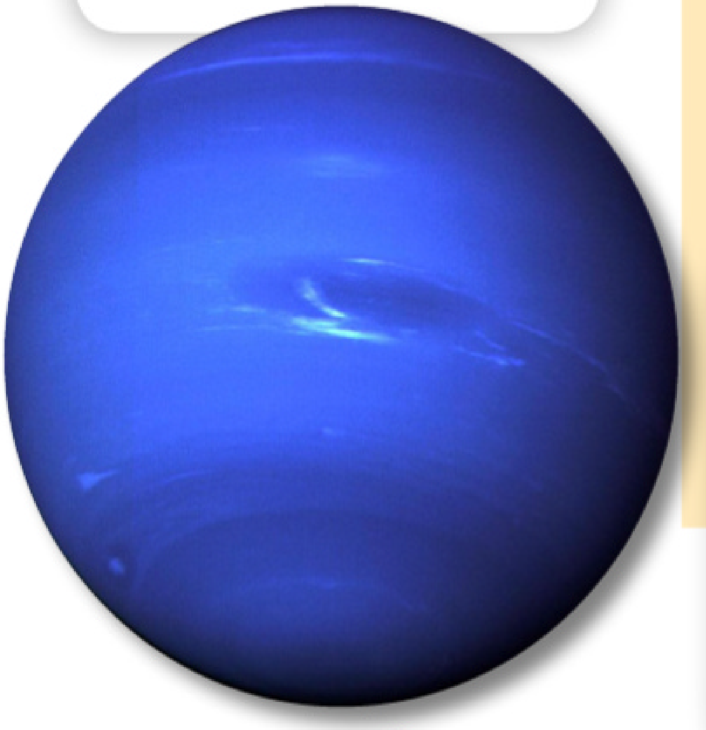
NEPTUNE IS THE EIGHTH and farthest planet from the Sun. It's the only planet whose position was predicted by astronomers, leading to its discovery September 23, 1846. Most of what we know about Neptune comes from the Voyager 2 spacecraft, which passed by it in August 1989.

Neptune's atmosphere has the strongest winds in the solar system. They blow as fast as 1,300 mph (2,100 km/h). As far as the amount of stuff in Neptune, it's right between Jupiter and Earth. Jupiter has 19 times Neptune's mass, while Neptune has 17 times Earth's mass.

Although Neptune and Uranus have similar atmospheres, their colors are different. Uranus is light blue-green, and Neptune is really blue. Scientists think extra gas in Neptune's atmosphere makes it bluer.

NEPTUNE FACTS

Mass: 225.8 trillion trillion pounds (17.15 times Earth's)
Diameter: 30,775 miles (3.9 times Earth's)
Distance from Sun: 2,793 million miles (30 times Earth's)
Length of year: 164.8 years (165 times Earth's)
Length of day: 16.11 hours (67.1% of Earth's)



NEPTUNE

PLUTO

Pluto

AND FINALLY WE COME TO Pluto. Clyde Tombaugh, a former Kansas farmboy who was working at Lowell Observatory in Arizona, discovered Pluto on February 18, 1930. He had been photographing the sky for nearly a year, taking two pictures of the same area several days apart. When he compared the ones he took on January 23 and 29, he discovered an object had moved — Pluto.

After the announcement of the discovery, Lowell Observatory received more than 1,000 suggestions for names of the new planet. In the end, Venetia Burney, an 11-year-old girl who lived in Oxford, England, got credit for suggesting the name "Pluto."

On August 24, 2006, a group of scientists who were part of the International Astronomical Union came up with a definition of the word *planet* that no longer includes Pluto. A lot of people are unhappy about this, but as of today, our solar system has only eight planets.

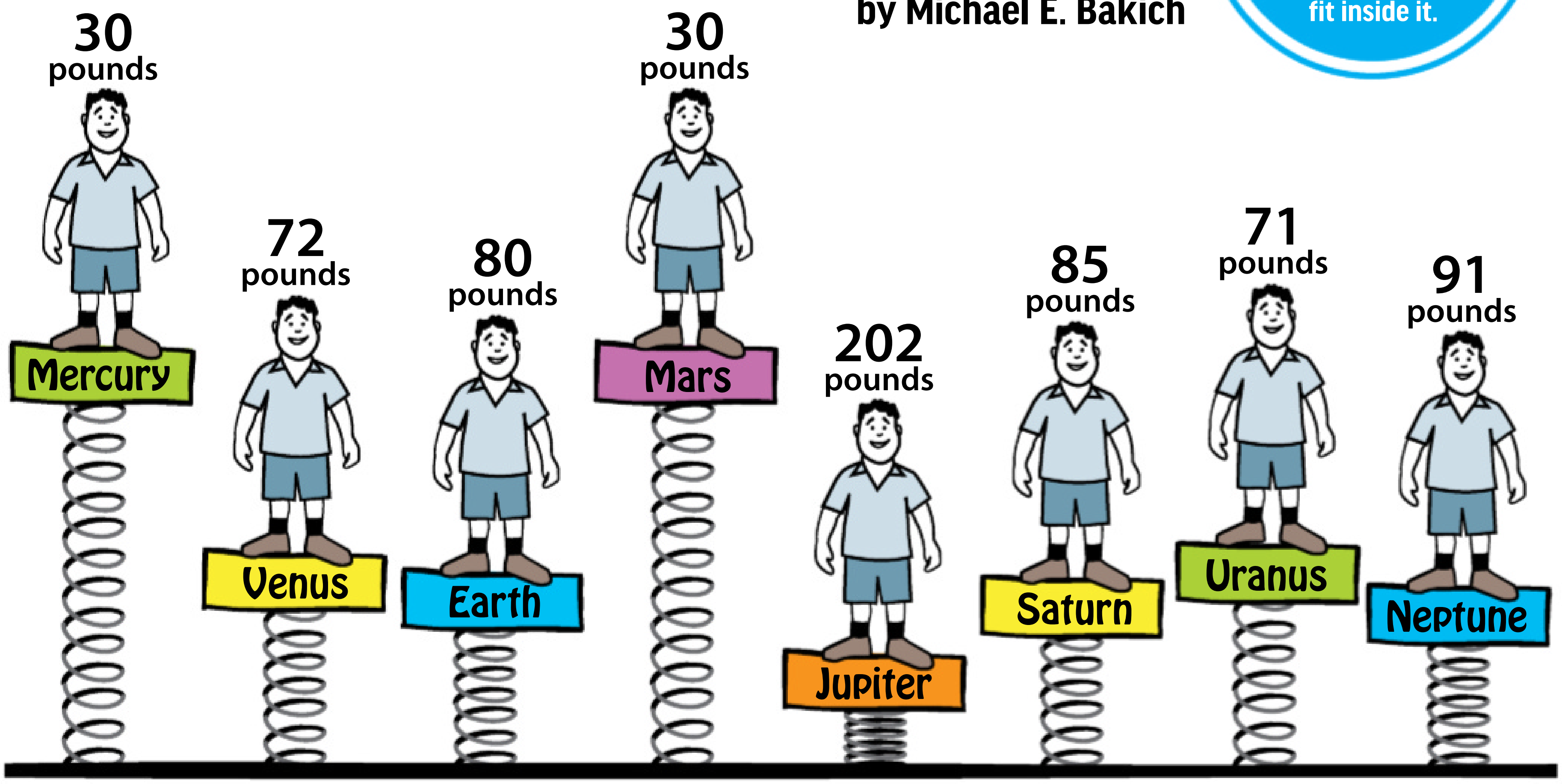
PLUTO FACTS

Mass: 0.0276 trillion trillion pounds (0.2% of Earth's)
Diameter: 1,476 miles (18.7% of Earth's)
Distance from Sun: 3,670 million miles (39.5 times Earth's)
Length of year: 248.0 years (248 times Earth's)
Length of day: 153.3 hours (6.4 times Earth's)

What would you weigh on another planet?

FUN FACT
Jupiter, the most massive planet, is also the largest. 1,266 Earths could fit inside it.

by Michael E. Bakich



ASTRONOMY: ROEN KELLY

THE AMOUNT OF GRAVITY something has depends on its mass — the amount of stuff in it. Because some of the planets of our solar system have large masses, they have stronger gravity than the ones with small masses.

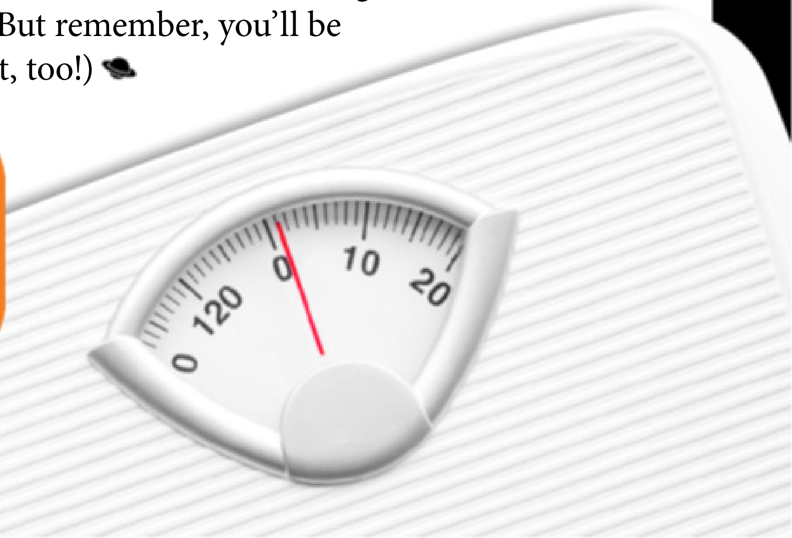
So, because the pull of gravity determines how much something (or someone) weighs, you'd weigh more on planets that have more mass than Earth, and you'd weigh less on those with less mass than Earth.

The diagram above shows how much you'd weigh on each planet if you weigh 80 pounds on Earth. (To convert those weights to kilograms, divide the numbers by 2.2 or multiply by 0.45.)

But what if you don't weigh exactly 80 pounds? No problem: Just take your weight and divide it by 80. Then choose a planet in the diagram above, and multiply your answer by the number at the top of that planet's scale (above the person's head).

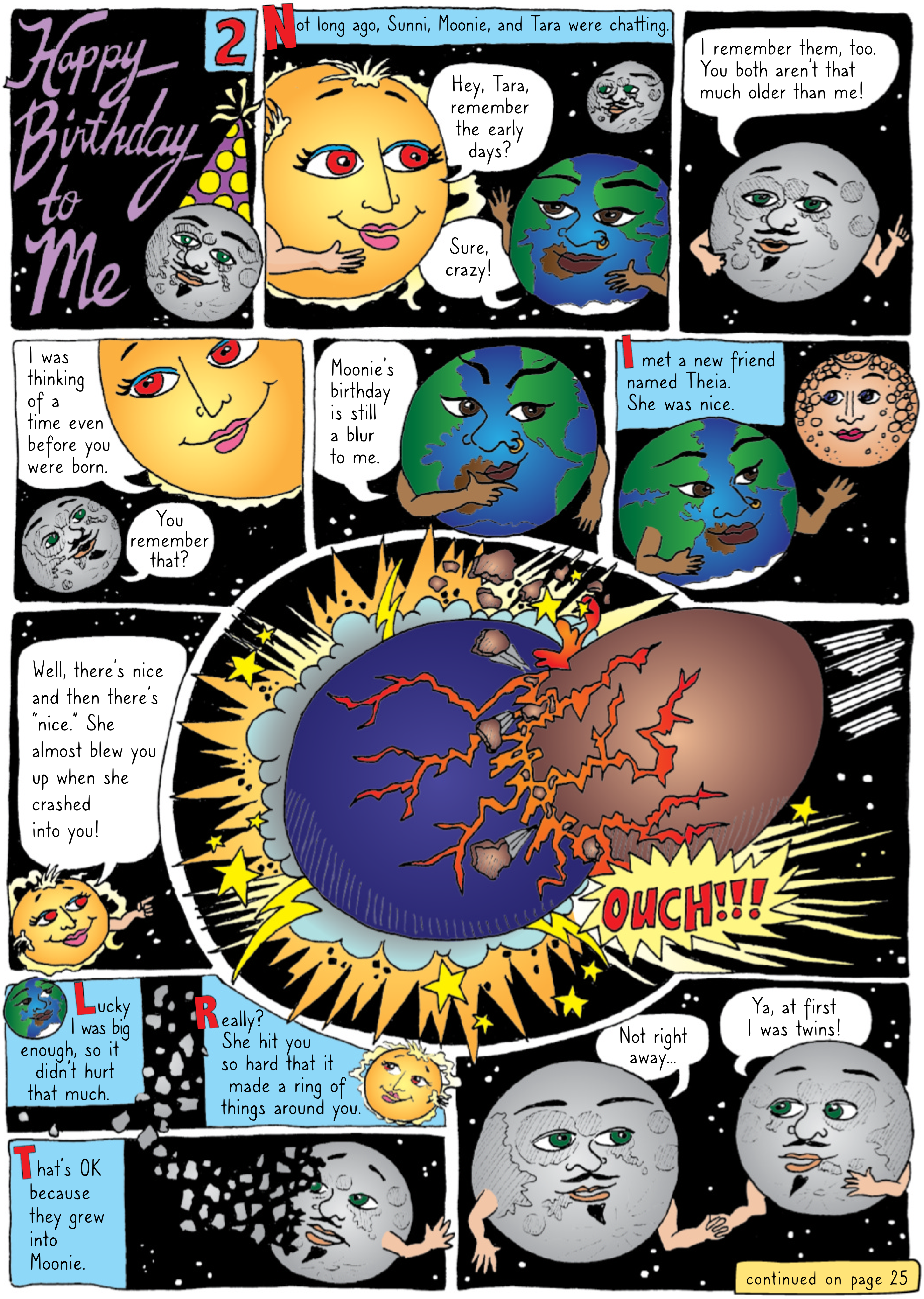
Here's an example: You weigh 93 pounds, and you want to know how much you'd weigh on Mars. First, divide 93 by 80. That gives you 1.16 (rounded off). Now just multiply 1.16 by 30, the number above Mars. You would weigh 34.8 pounds on Mars. (But remember, you'll be wearing a spacesuit, too!)

FUN FACT
Earth weighs 6,600,000,000,000,000,000,000 tons.

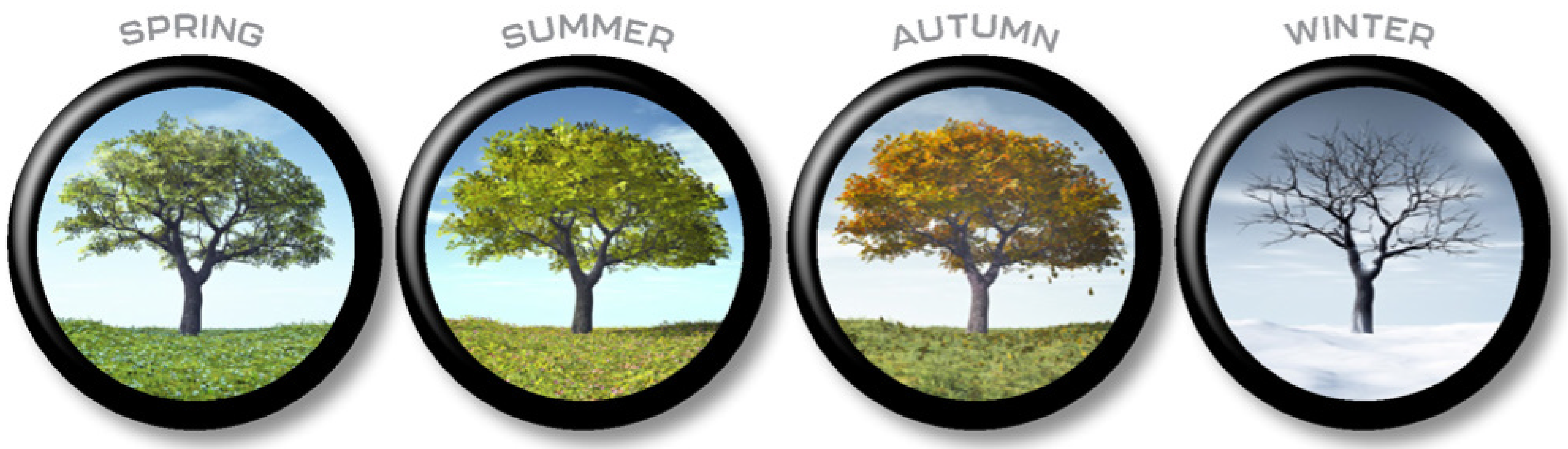


SCALE: 9DREAMSTUDIO/DREAMSTIME

Happy Birthday to Me


2
Not long ago, Sunni, Moonie, and Tara were chatting.
Hey, Tara, remember the early days?
Sure, crazy!
I remember them, too. You both aren't that much older than me!
I was thinking of a time even before you were born.
You remember that?
Moonie's birthday is still a blur to me.
I met a new friend named Theia. She was nice.
Well, there's nice and then there's "nice." She almost blew you up when she crashed into you!
OUCH!!!
Lucky I was big enough, so it didn't hurt that much.
Really? She hit you so hard that it made a ring of things around you.
Not right away...
Ya, at first I was twins!
That's OK because they grew into Moonie.

continued on page 25



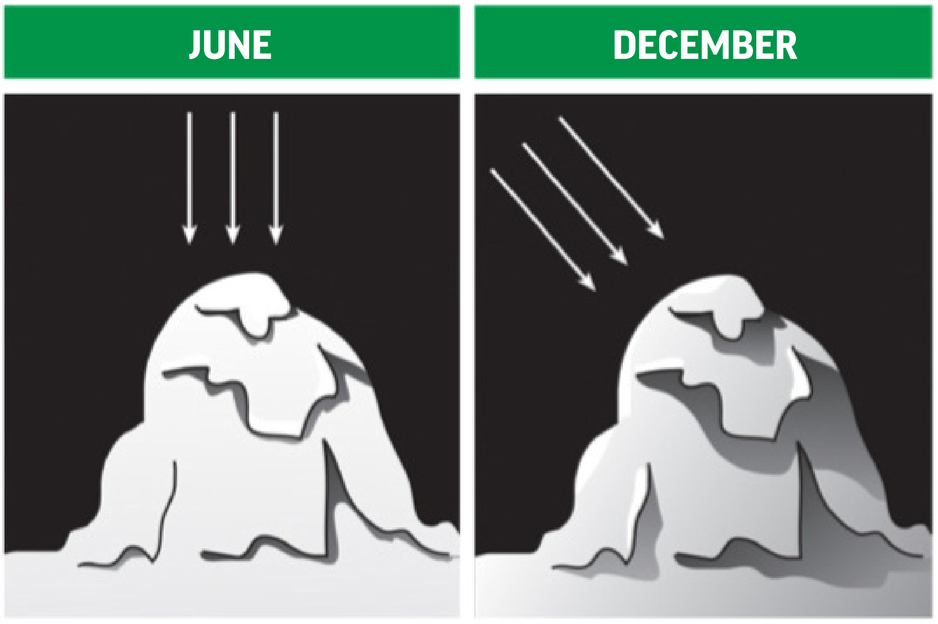
The reason for the SEASONS

by Michael E. Bakich

WHAT'S A SOLSTICE? WHAT'S AN EQUINOX? AND HOW CAN YOU USE THE SUN TO TELL YOU WHEN THEY'VE ARRIVED?

When Earth spins, it makes day and night. That spin makes it look like the Sun moves through our sky. We see it rise in the east in the morning and set in the west in the evening. But if you track the Sun through the year, you'll find that it also gets higher and lower in the sky.

But it can't just keep going up and up or going down and down. It has to stop sometime. The days when the Sun stops moving higher or lower are called solstices.



HOLLEY BAKICH

In June, the Sun is higher, so we get more direct sunlight. In December, the same amount of sunlight spreads out, so we have cooler temperatures.

Important dates

Each year, there are two solstices. One happens around June 21, so we call it the June solstice. That's when the Sun stops climbing higher in the sky. It's the first day of summer in the Northern Hemisphere, so you'll also hear it called the summer solstice. It's also the longest day of the year.

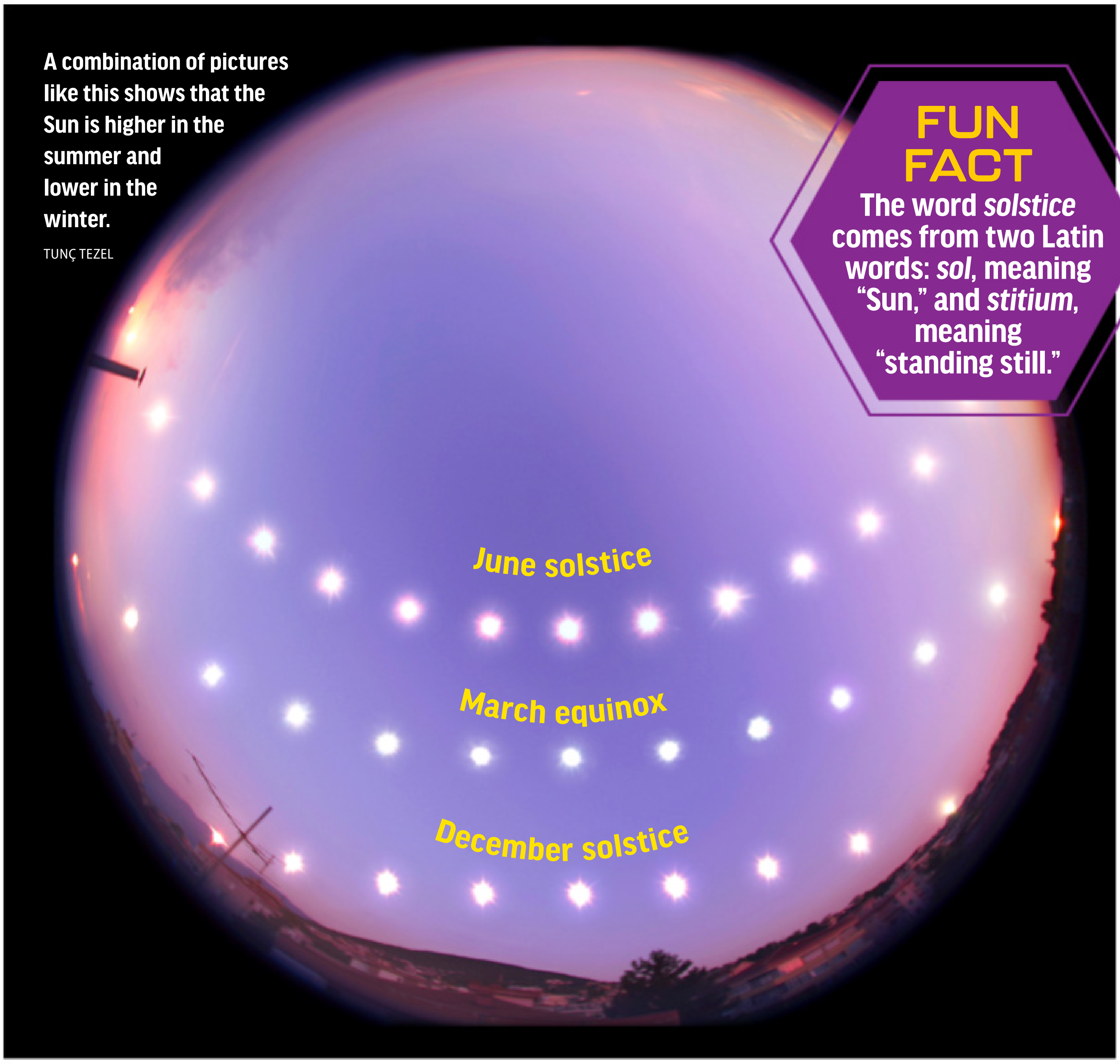
The other solstice happens near December 21. You can call it the December solstice or the winter solstice. On that date, the Sun is lowest in the sky, and it's the first day of winter. It's also the shortest day of the year.

The Sun is halfway between these points twice a year. On March 21, it's getting higher in the sky. On September 21, it's getting lower. We call these two days equinoxes. On these days, day and night last for 12 hours each. The March

FUN FACT

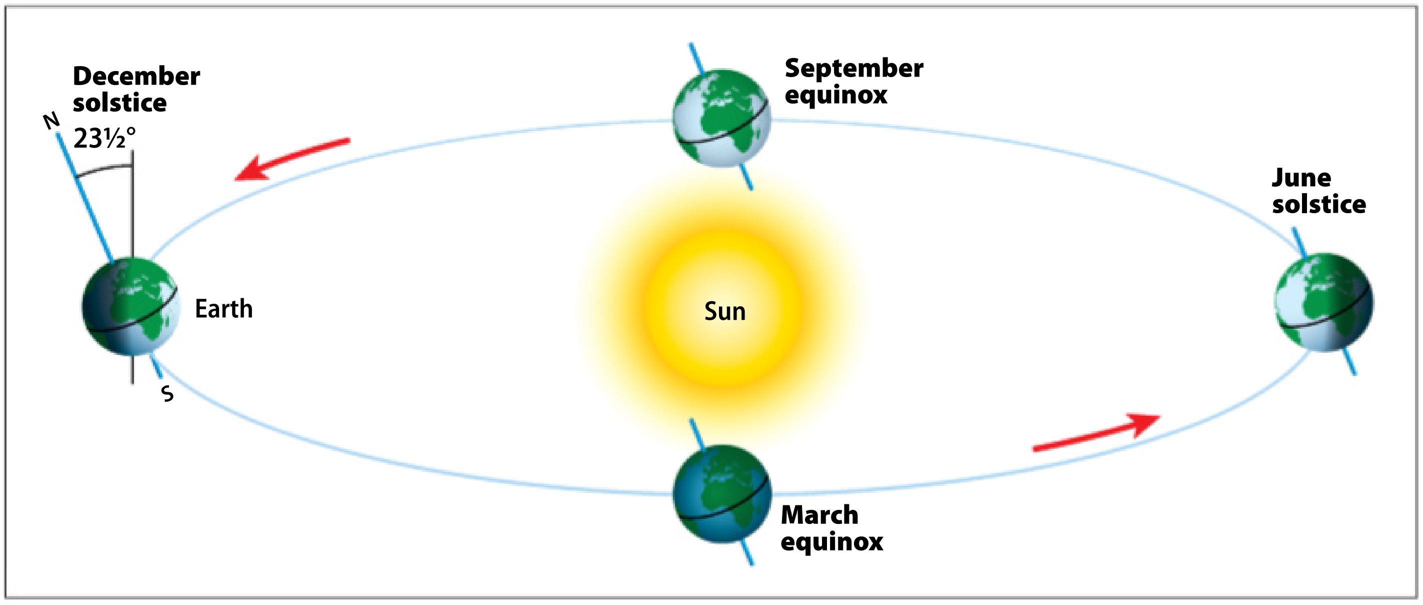
The word *equinox* comes from the Latin words *aequi* and *noctium*, which mean "equal night."

SEASONAL TREES: MARKUS GANN/DREAMSTIME. LEAF: PHOTKA/DREAMSTIME. SNOWFLAKE: MAYA KRUCHANKOVA/DREAMSTIME



A combination of pictures like this shows that the Sun is higher in the summer and lower in the winter. TUNÇ TEZEL

FUN FACT
The word *solstice* comes from two Latin words: *sol*, meaning "Sun," and *stitium*, meaning "standing still."



Earth's seasons begin when our planet gets to four places in its orbit: two solstices and two equinoxes. HOLLEY BAKICH

equinox is the start of spring, and the September equinox is the beginning of fall or autumn.

A tilting planet

So, these dates are when our four seasons start. But why does Earth have seasons? It's because our planet tilts 23½° on its axis. The axis is the imaginary line between the North Pole and the South Pole that our planet spins on.

Earth's axis always points to the same two spots in space no matter where Earth is in its orbit around the Sun. Sometimes (around June 21) our planet tilts toward the Sun. Six months later (around December 21), it tilts away from the Sun.

Between March 21 and September 21, the north half of Earth gets the most sunlight. That means the days are longer and the nights are shorter. In the other half of the year, it's the south part of our planet that gets the extra light, so for those six months, our days are shorter, and our nights are longer.

You may think it's the extra daylight that causes warmer temperatures in summer, and those hours do help, but that's not the main reason. Instead, it's the angle of the sunlight that's hitting Earth. A flashlight can show you why.

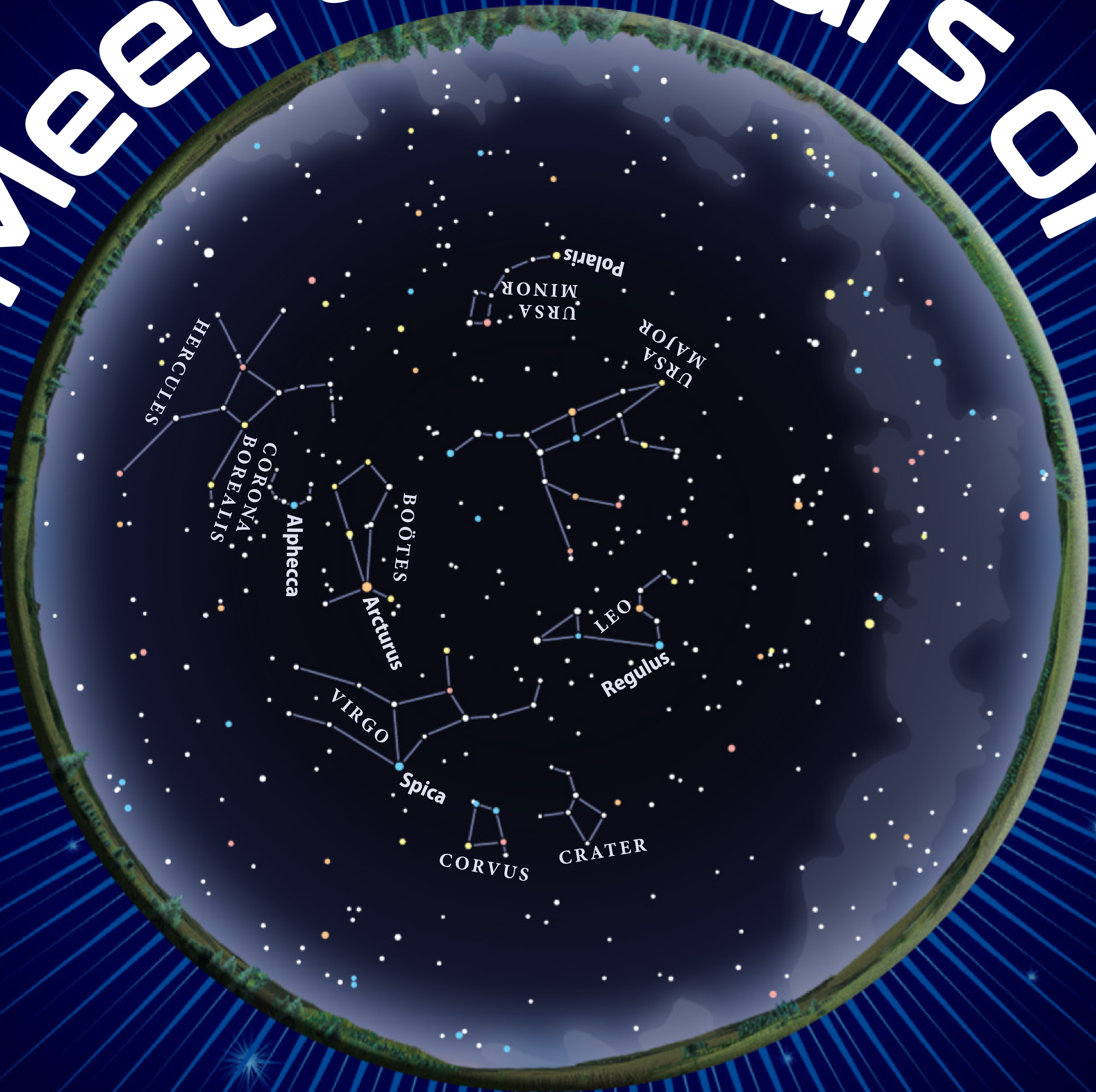
Turn off the lights in your room, and turn on the flashlight. Aim the flashlight straight down and you'll see a circle of light on the floor. Now tilt the flashlight a little. What happens to the circle? It stretches out. The more you tilt the flashlight, the bigger the pattern of light gets. It's the same amount of light, but the light in the small circle is more concentrated than the light in the bigger oval.

Think of the flashlight as the Sun. The light on the floor is the Sun's energy. The small, bright circle happens in the summer when the Sun is high in the sky. The dimmer, spread-out oval happens in the winter when the Sun is lower. And the more direct the sunlight is, the more it warms that part of Earth.

But that brings up a good question: Why isn't June 21 the hottest day of the year? Or December 21 the coldest? The reason is that the atmosphere and the oceans take a while to warm up after the cold weather in the winter and to cool after the hot summer weather. So, we don't feel the full effects until six or eight weeks after the June or December solstices.

Lots of people like summer, but everyone has their own favorite season. No matter which season you're in, you can follow the Sun throughout the day. The fun activity you'll find on p. 28 will help you do just that.

Meet the stars of SPRING


Polaris
URSA MINOR
URSA MAJOR
HERCULES
CORONA BOREALIS
Alphecca
BOÖTES
Arcturus
LEO
Regulus
VIRGO
Spica
CORVUS
CRATER

by Raymond Shubinski

The Big Dipper, the brightest part of the constellation Ursa Major the Great Bear, rides high in the sky. Poke a hole in the bottom of the Dipper's bowl, and the water would fall on the back of Leo the Lion. Then use the two stars at the end of the bowl, called the Pointer Stars, to lead you to Polaris, the North Star. *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

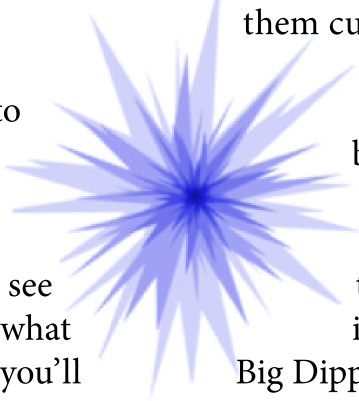
MOST PEOPLE LIKE SPRING. The weather is starting to warm up, and the days are still short enough to let us look at the stars early in the evening. So, you won't have to stay up late to see them.

Probably the best time to go outside is about an hour after sunset. One thing you'll notice — and this is true for all four seasons — is that if you look at the stars at the same time each night, they'll be in different places at the end of spring than they were at the beginning. This happens because Earth is traveling around the Sun.

Start by facing north, and look for one of the most famous constellations, Ursa Major the Great Bear. If you're at a dark place and have a good star map, you might be able to find all of the bear's stars. But it isn't easy because most of them aren't very bright. So, just look for the Big Dipper — it's the easiest part of Ursa Major to see.

The Dipper is seven bright stars: four in the bowl and three in the handle. On a spring night, the Big Dipper is high in the sky, but it will be upside down. This is a great place to start because the Dipper can be your guide to other stars and constellations.

Probably the most important star you can find is Polaris the North Star. Use the two stars at the end of the Dipper's bowl. They're called the Pointer Stars. Draw a line through them to the North Star. Then, from the North Star, drop a line to the ground. That direction is north. (That's why it's called the North Star.) You can find the other directions now. If you face the North Star, east is to your right, and west is to your left. The fourth direction is the easiest to find: South is behind you, on the other side of the sky from the North Star.



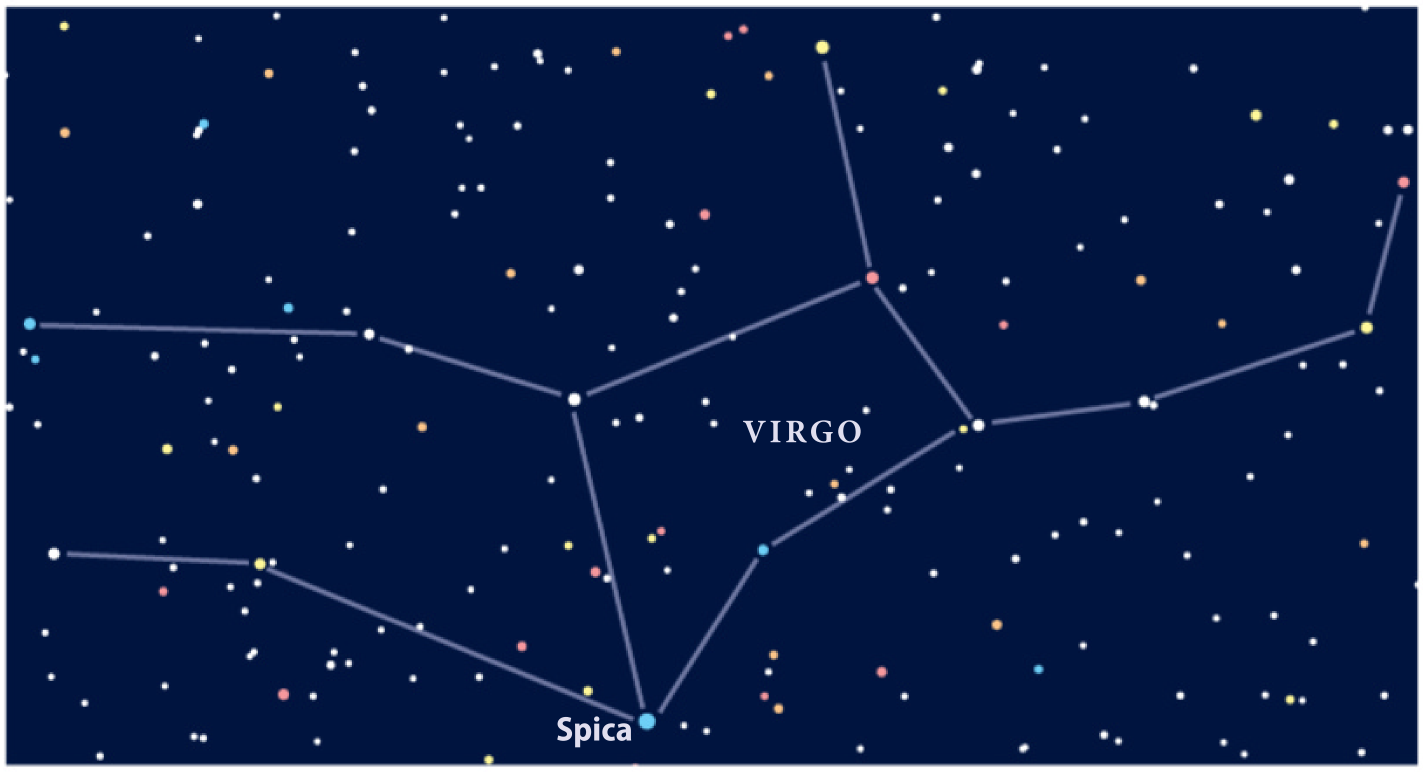
Here's a really important thing to remember about the North Star: No matter what time of night you see it, and no matter what time of year it is, you'll always find it in the same place. That's because Earth's axis, the imaginary line between the North Pole and the South Pole, points north to Polaris. So, that star doesn't seem to move. (Actually, it does move, but only a tiny bit, so we don't notice it.) But all the other stars circle the North Star. Some of the circles are so huge that we don't see the whole circle. Those stars rise in the east and set in the west. Half of their circles are hidden by the ground. But if Earth weren't in the way, we'd see that they move in circles, too.

Polaris is the brightest star in the constellation Ursa Minor the Bear Cub. And just like with Ursa Major, the easiest part of the Cub to find is the part we call the Little Dipper. Most of its stars are dim, but from a dark place, you can see them curving back toward the Big Dipper.

OK, if you head back to the Big Dipper, you can find other things in the sky. Poke a hole in the bottom of the Big Dipper's bowl so that all the water runs out. Listen closely — did you hear a great roar? It came from Leo the Lion, because he got wet when the water from the Dipper fell on him.

Leo sits under the Big Dipper, and he's easy to see. The Lion's head and mane looks like a big backward question mark, his body is a long box, and his hind legs and tail are a triangle of

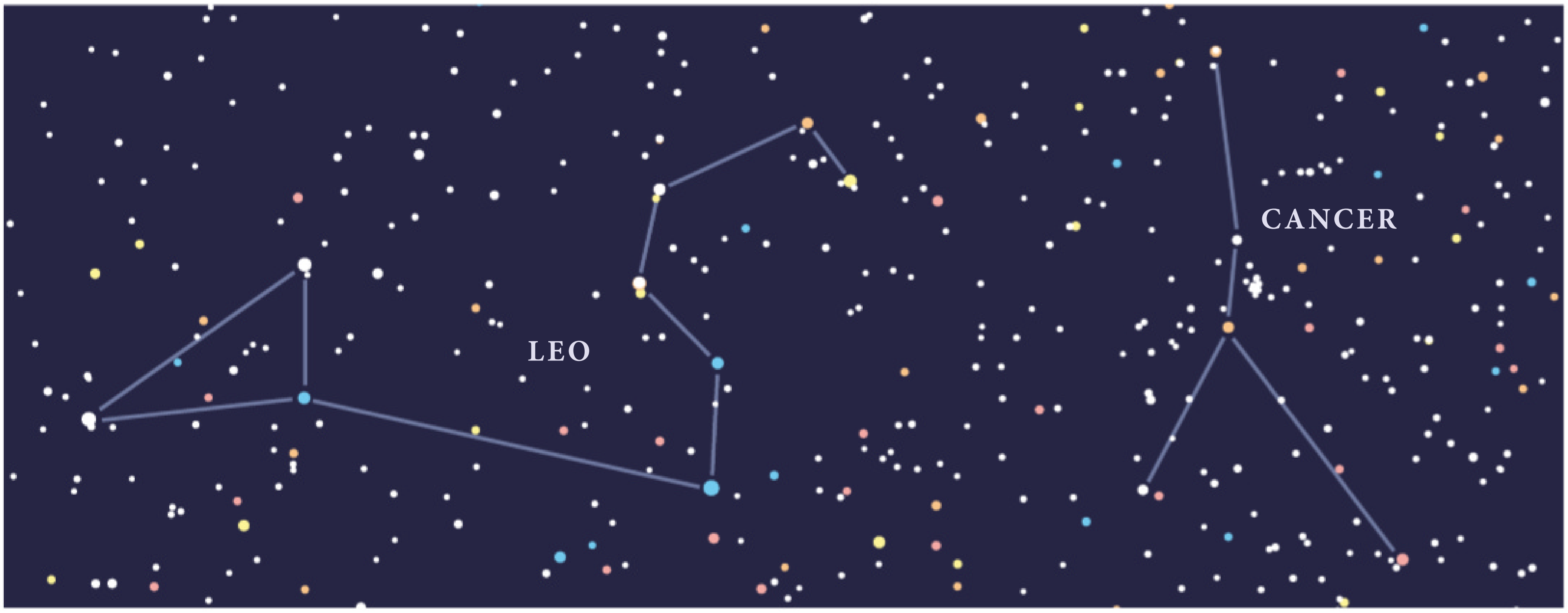
Virgo the Maiden is the second-largest constellation of the 88 that fill the sky. Its brightest star is Spica, which is a lot hotter than the Sun. *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

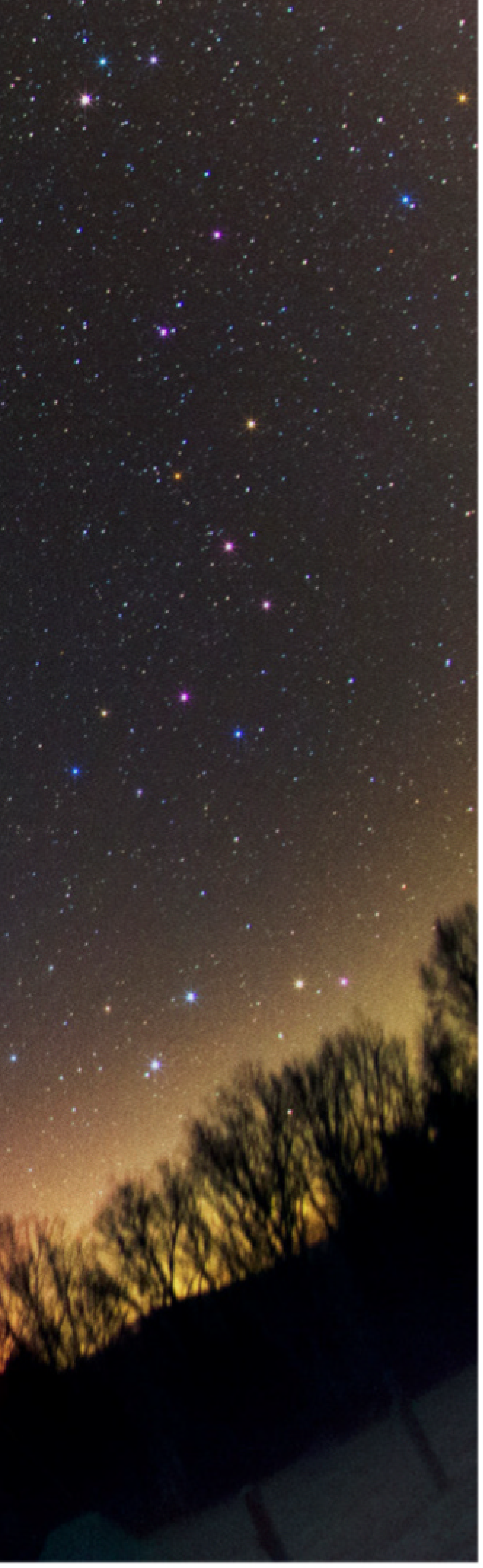


OPPOSITE PAGE BACKGROUND: NATALIA KUCHUMOVA/DREAMSTIME. STARBURST: ILLIA HRYHORIEV/DREAMSTIME. CHILDREN: ANNA VITEEVA/DREAMSTIME

Use the chart on page 20 and see how many stars and constellations you can identify in this photograph of the spring sky.

JOHN CHUMACK





The constellations Leo the Lion and Cancer the Crab lie next to each other. Leo is easy to see. Cancer is faint and hard to see. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

stars. The "dot" at the bottom of the question mark is Leo's brightest star, Regulus. People have imagined a lion in this part of the sky for thousands of years. One story tells about Hercules, a hero from Greek and Roman mythology, and a fight he had with Leo. Hercules won the battle, and now both he and the lion are in the sky. You'll see Hercules in a few months in the summer sky.

After you find Leo, go back to the Big Dipper and follow a curved line down from the handle. Soon you'll find the bright star Arcturus in the constellation Boötes the Herdsman. Some stories say Boötes is a man chasing the Great Bear around the sky. Others say he's herding goats. It's hard to picture a man there, so look for a giant kite in the sky, with Arcturus marking its pointed bottom.

Close to Boötes is a small constellation named Corona Borealis. Constellation and star names can come from the Latin, Greek, or Arabic languages. The name of this star group is Latin, and it means "the northern crown." The stars of Corona Borealis are not bright. But if the sky is dark, you can see what looks like a small bowl. The crown's brightest star has an Arabic name, Alphecca.

Next, go back to the handle of the Big Dipper. Follow the curved line to Arcturus, but this time, keep going until you find Spica, the brightest star in the constellation Virgo the Maiden. Spica is blue-white star whose light takes 250 years to reach Earth.

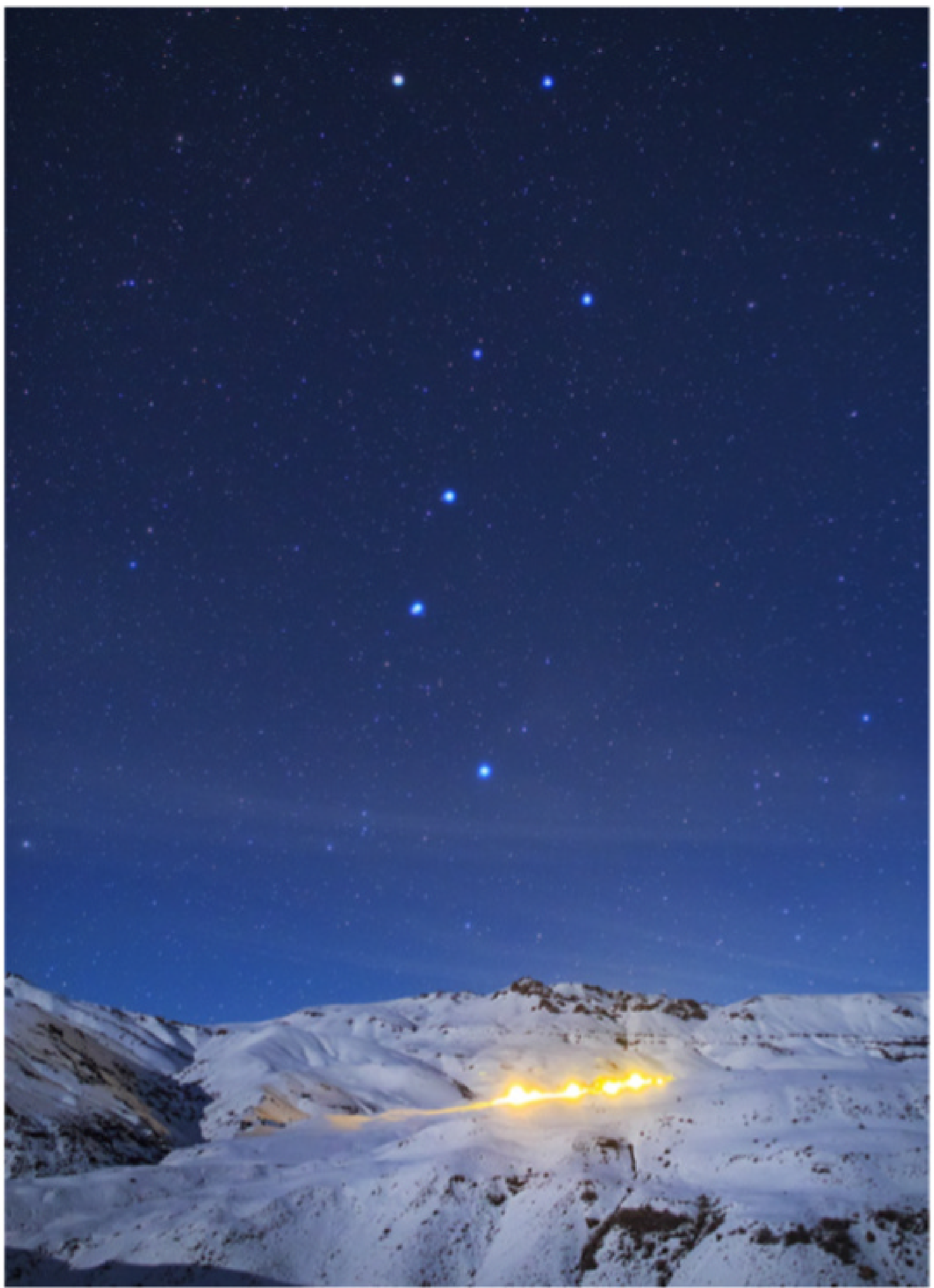
Thousands of years ago, Virgo was the most important of all spring constellations. When farmers first saw Spica rising early in the evening, they knew spring had started and it was time to plant their crops. Later in the year, when Spica was setting not long after sunset, the same farmers knew it was time to harvest their crops.

Below Virgo are two small springtime constellations: Corvus the Crow and Crater the Cup. The crow looks like a lopsided rectangle whose top two stars point to Spica, just like the Pointer Stars point to the North Star. Just to the right of Corvus is Crater. It's tough to see, but it really does look like a small cup.

Legend tells us the cup belonged to the Sun god Apollo, who was angry with Corvus for spying on him and telling his secrets. To punish him, Apollo chained Corvus to a rock and put a cup of water just far enough away so that the crow couldn't get to it. So, Corvus can never quite reach the cup to quench his thirst, and the story says this is why crows have such rasping calls.

SPORTS EQUIPMENT: CHONESCHONES/DREAMSTIME

The Big Dipper rises over a mountain village in Iran. Notice how it stands on its end when it rises. JEFF DAI



See the SUN safely

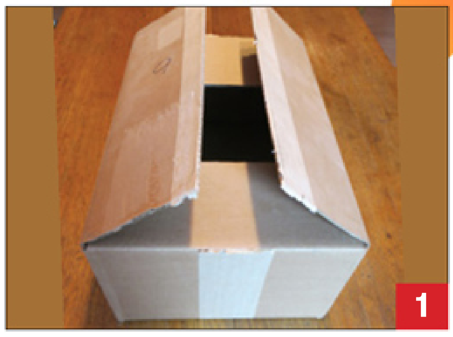
by Mike Reynolds

YOU WANT TO LOOK AT THE SUN, but you don't have a solar filter for your telescope. Maybe you don't even have a telescope. No problem!

Somewhere at home, we'll bet you have a cardboard box. That and a few other things will let you build a "pinhole viewer" for the Sun. And even though the Sun will look tiny, it will be the Sun, and you can watch it as long as you want. This viewer is totally safe — and also pretty close to free.

Just follow these steps. Feel free to change the size of the box and decide whether you want to cut off the extra cardboard pieces. You also can try using a thicker pin or a sharp pencil to see if it gives you a better-looking Sun.

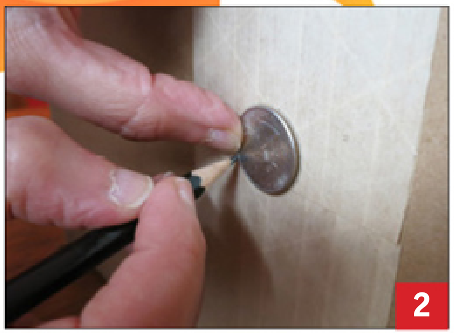
Remember that you're not building a telescope, so you won't see much detail. But that white circle will definitely be the Sun.



1

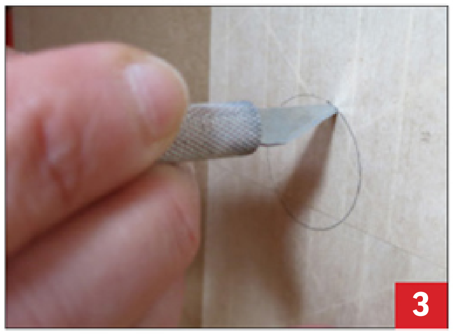
Start with a cardboard box at least 18 inches (46 centimeters) long. If you use a box shorter than this, the image of the Sun will be tiny.

ALL PHOTOS: HOLLEY BAKICH



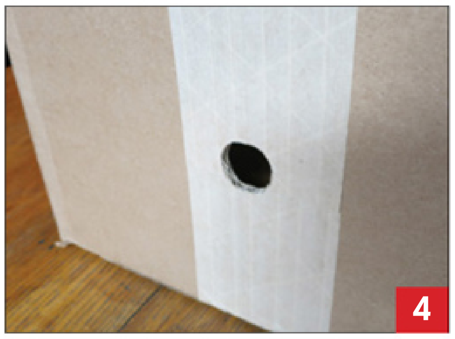
2

In the center of one of the box's small ends, trace a circle around a quarter. You could use a nickel, a dime, or a penny, too.



3

Ask an adult to carefully cut out the circle with a sharp knife.

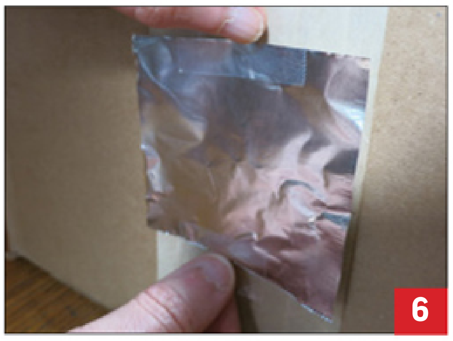


4

The hole doesn't have to be perfect — or even round!

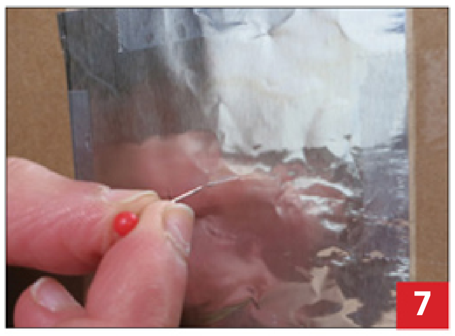
5

Cut out a small piece of aluminum foil big enough to cover the hole in the box. The best foil to use is a heavy-duty kind.



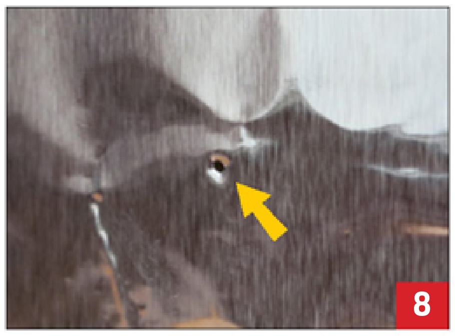
6

Tape the foil over the hole.



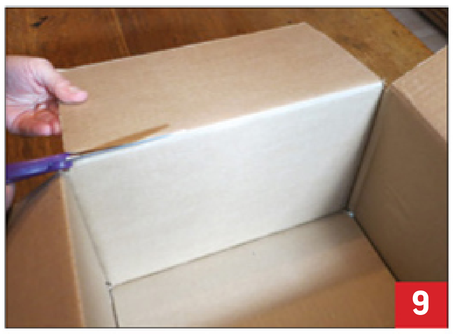
7

Poke a hole in the foil using a pin. A pin is better than most items you could use because you want a hole with clean (not ragged) edges. If you don't have a pin, use a sharp pencil. But don't make the hole too big. A bigger hole lets more light through and makes a brighter Sun, but if your hole is too big, you'll just see a blob.



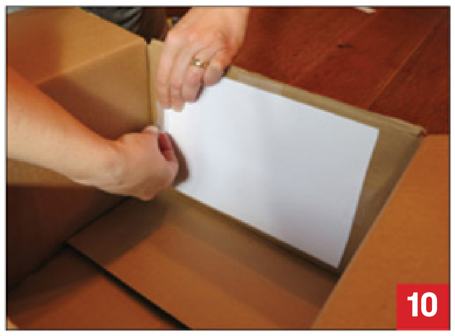
8

Make sure the hole is round and that nothing is blocking it.



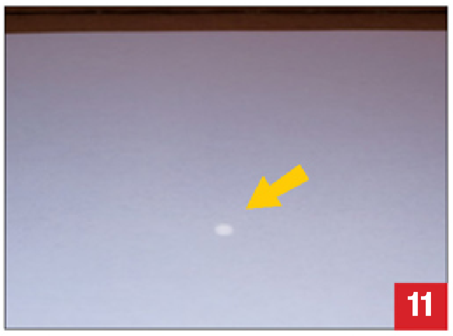
9

Cut away as much of the extra cardboard pieces as you want. Or fold them over and tape them to the box's sides. That will make the viewer a bit sturdier.



10

Tape a white piece of paper on the inside of the box opposite the hole.



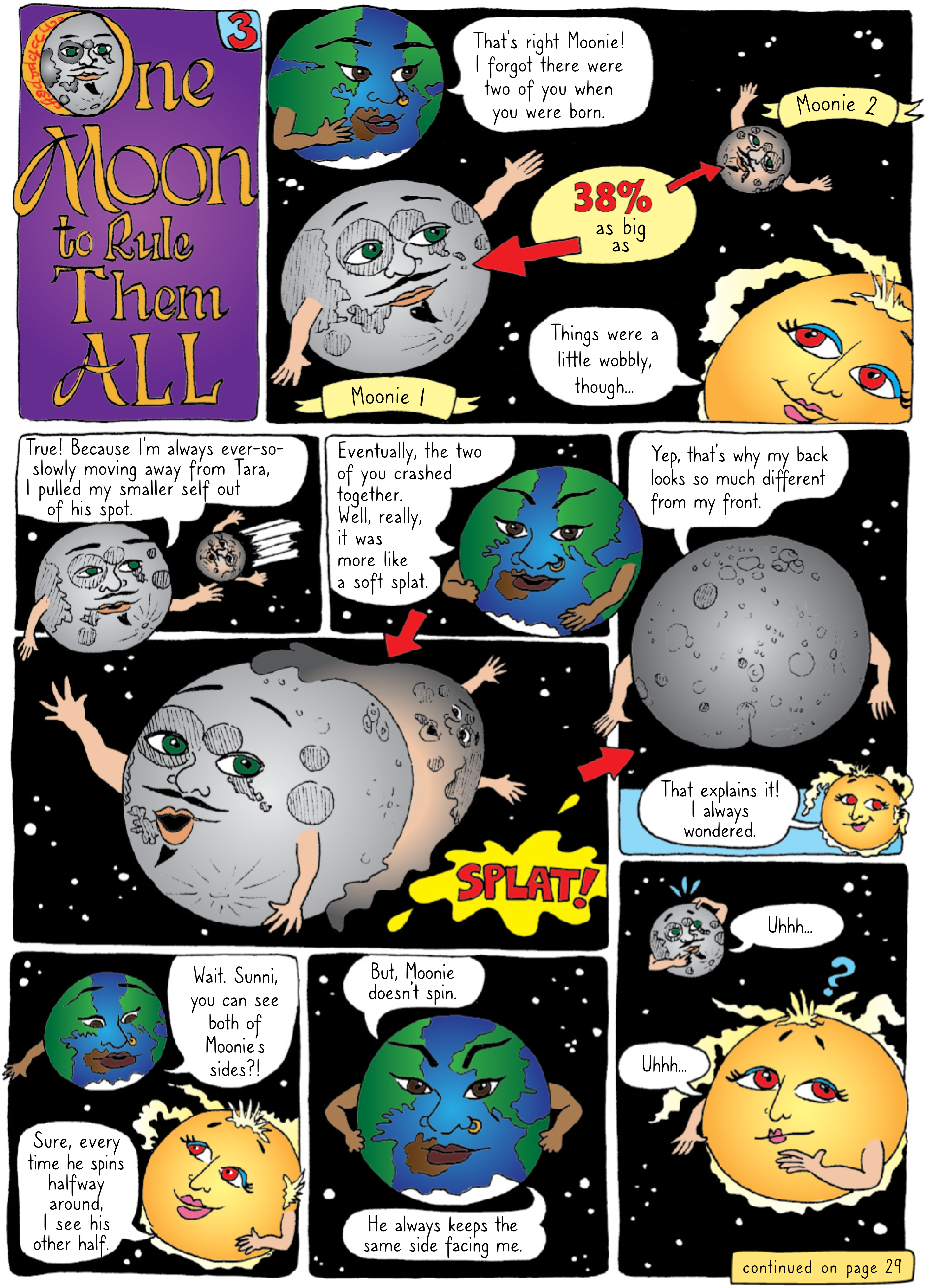
11

Point the hole at the Sun and look at the paper. Congratulations! That's the Sun.

Q: Why does a space rock taste better than an Earth rock?

A: Because it's a little meteor.

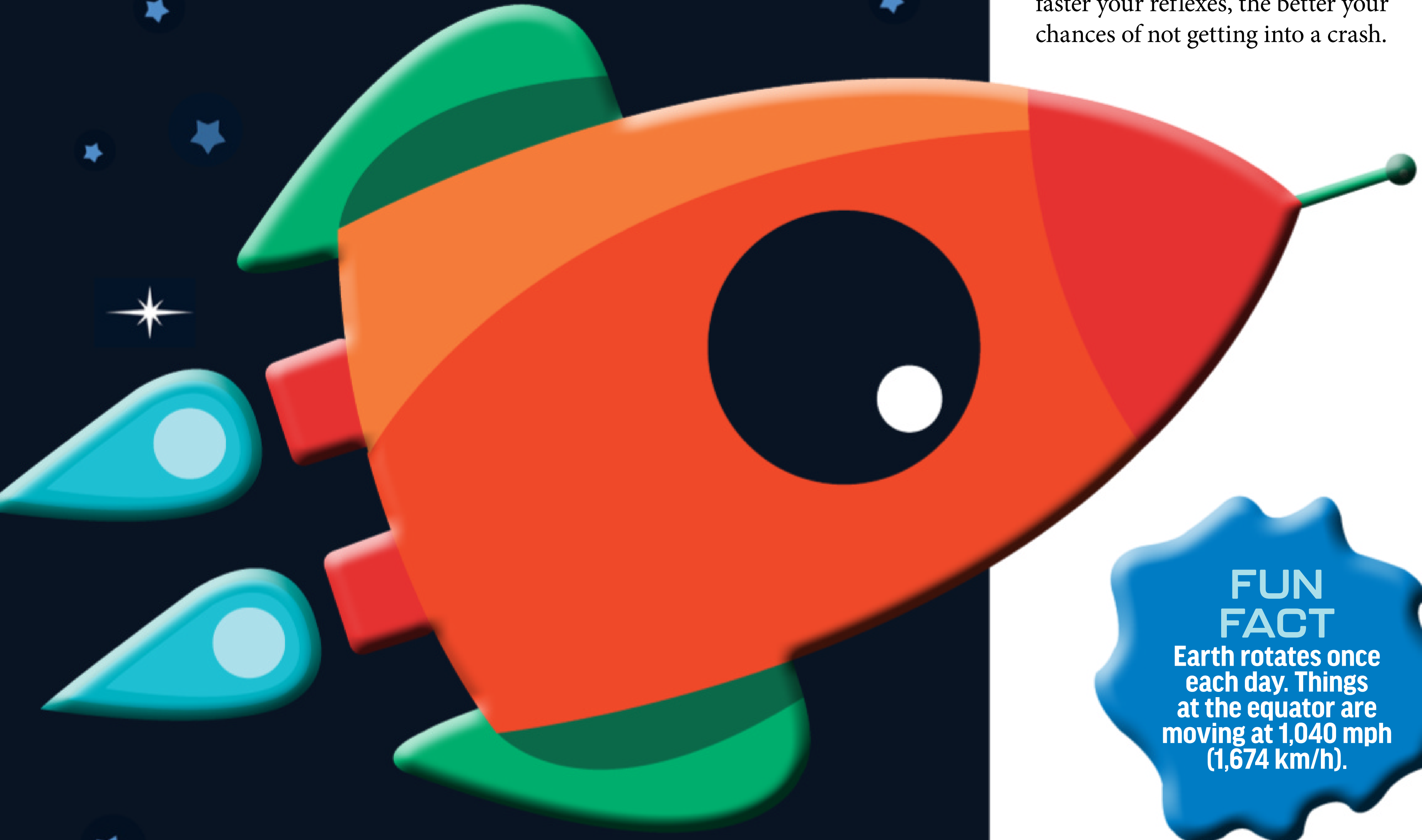
ALIEN: DANIELFELA/DREAMSTIME. SUN: EVGENII141/DREAMSTIME


One Moon to Rule Them ALL
3
That's right Moonie! I forgot there were two of you when you were born.
Moonie 2
38% as big as
Moonie 1
Things were a little wobbly, though...
True! Because I'm always ever-so-slowly moving away from Tara, I pulled my smaller self out of his spot.
Eventually, the two of you crashed together. Well, really, it was more like a soft splat.
Yep, that's why my back looks so much different from my front.
SPLAT!
That explains it! I always wondered.
Wait. Sunni, you can see both of Moonie's sides?!
Sure, every time he spins halfway around, I see his other half.
But, Moonie doesn't spin.
He always keeps the same side facing me.
Uhhh...
?
Uhhh...

continued on page 29

How fast are you?

by Michael E. Bakich



IMAGINE THAT YOU'RE THE PILOT of a spacecraft 100 miles (161 kilometers) above Earth. Your craft has a new advanced radar system, and it suddenly warns you that an asteroid is headed straight for you. You respond by firing your spacecraft's rockets to get out of the way. But were you fast enough? Will the asteroid miss you? In moments, you'll know.

If you drive a car on Earth, you need split-second reflexes to avoid crashes. If another car suddenly pulls in front of you, you have to hit the brakes hard. If you're traveling 50 mph (80.5 km/h) and let just one second pass before you hit the brakes, your car will travel 73 feet (22 meters) before it begins to slow down. If you wait only half a second, the car will travel 36.5 feet (11 m). So, the faster your reflexes, the better your chances of not getting into a crash.

FUN FACT

Earth rotates once each day. Things at the equator are moving at 1,040 mph (1,674 km/h).

WHAT! YOU'LL NEED

☐ Yardstick
☐ Glue
☐ Scissors
☐ Blindfold
☐ A friend

Details

Fast reflexes are even more important in space because spacecraft travel much faster than cars. To figure out how many feet a spacecraft traveling at 18,000 mph (29,000 km/h) will travel in one second, we first figure out how many feet it will travel in one hour:

18,000 mph x 5,280 feet per mile = 950,040,000 feet per hour

Now let's figure out how far it goes in one second:

950,040,000 feet per hour ÷ 3,600 seconds per hour = 26,400 feet per second

In one second, the spacecraft will travel 26,400 feet, or about 5 miles (8 km)! So, even one second may be too long to wait to take action.

OK, how fast are your reflexes? Can you beat one second? Chances are you can do a lot better than that. Try this experiment to find out just how fast you are, and whether or not you would make a good astronaut.

FUN FACT
Earth travels around the Sun at 66,600 mph (107,200 km/h).

What to do

1 Cut out or copy the patterns in this activity. Glue them end-to-end to a yardstick. The thumbprint should be at the end of the yardstick, which is now your timer.

2 Brace your arm on a table so that just your hand sticks out over the edge. Spread your thumb about 3 inches (7.5 centimeters) from your other fingers.

3 Have a friend hold the yardstick so the bottom is just between your thumb and fingers. The thumbprint on the scale should be directly in line with your thumb.

4 Without warning, your friend should drop the yardstick and you should try to catch it.

5 Record the number under your thumb where you stopped the yardstick. This number tells you how fast your reflexes are in hundredths of a second.

6 For a fair test, do the experiment at least four more times and then average your times. To find the average, add up all the times and then divide by the number of tries.

7 Trade places and test your friend's reflexes.

Now try this

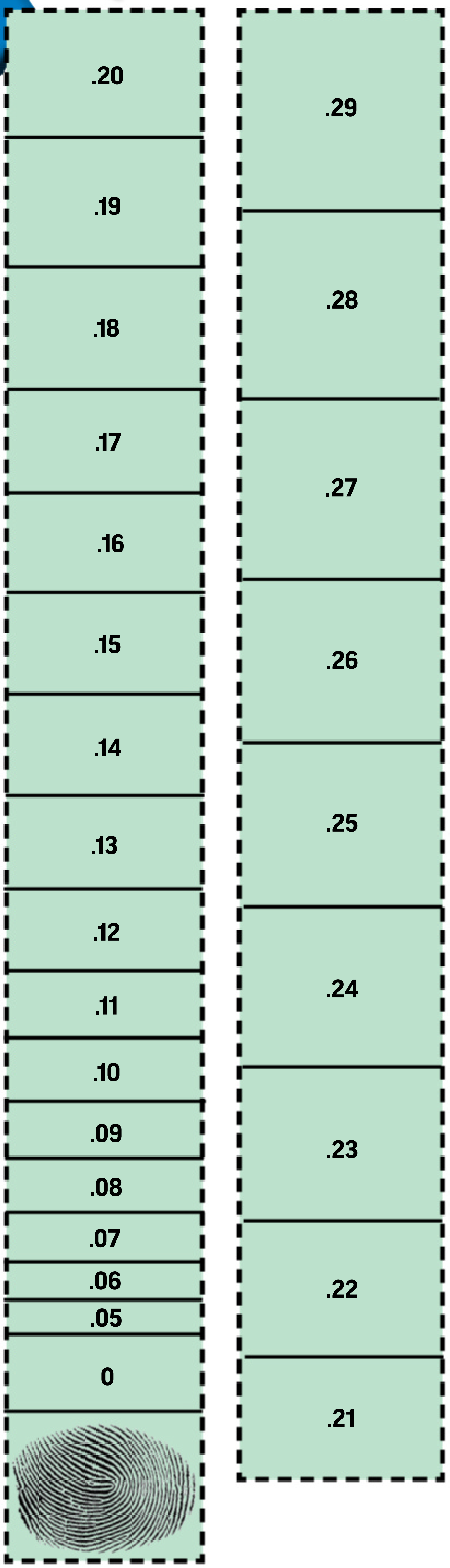
You just figured out the speed of your reflexes from what you saw. How well do you think you would do if you were blindfolded?

To try this, set up the experiment like before, then put on a blindfold. This time, your friend should say, "Now!" at the exact moment he or she lets go of the yardstick. Were your reflexes faster or slower than when you used your eyes?

Your score

If your reflexes come in somewhere between 0 and 0.29 (a little less than a third of a second), you should make a good pilot astronaut. If not, don't worry — there are lots of other jobs in space! Maybe you'll be a mission specialist.

CUT THESE OUT!



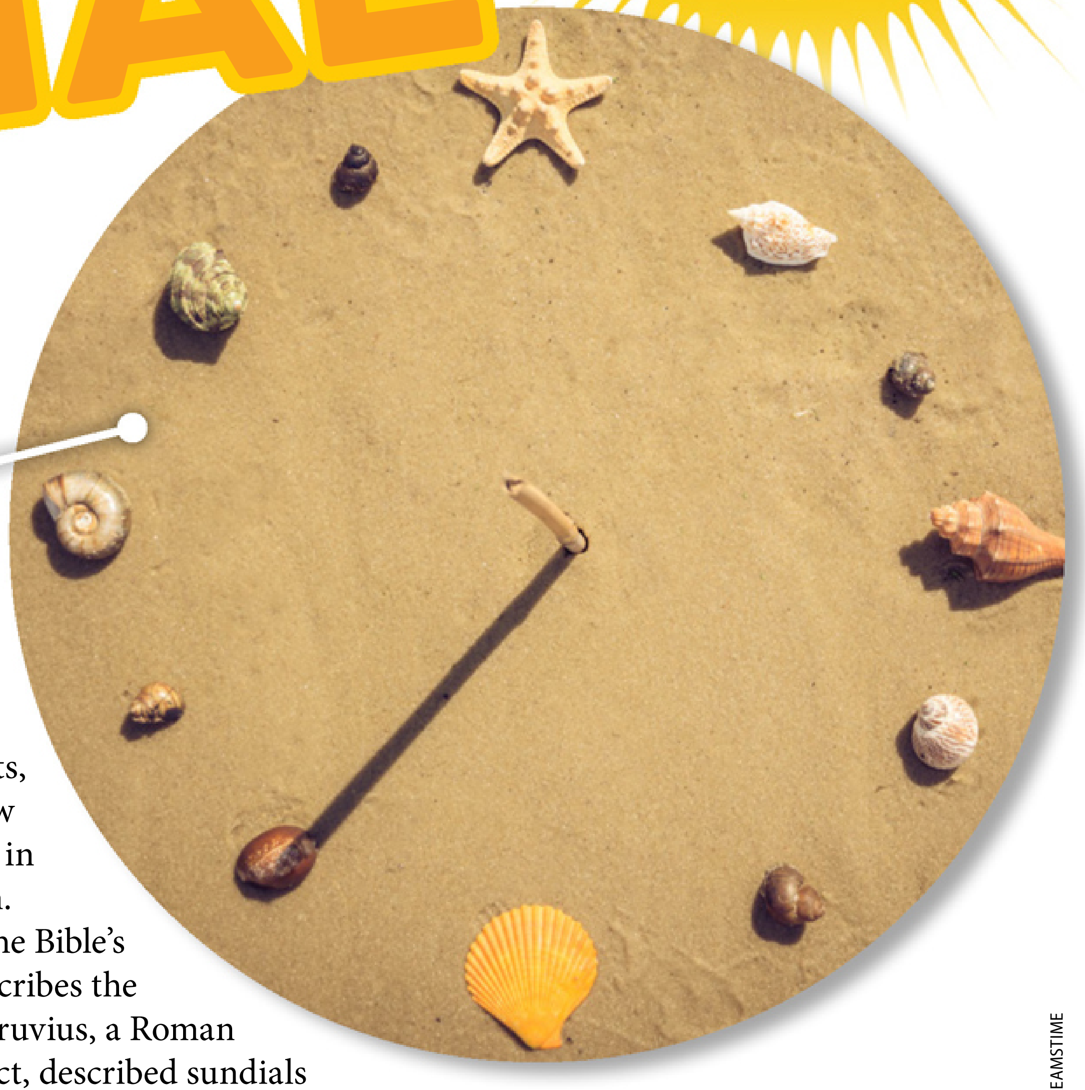
ILLUSTRATIONS: RAGERABBIT/DREAMSTIME. SCISSORS: PEERASAK KAMNGOEN/DREAMSTIME

Make a simple SUNDIAL

by Mike Reynolds

FUN FACT

If you can't find a spot for your sundial, you can use a clothes pole or even a flagpole as the gnomon. Anything will work as long as it's straight, fairly long, and points upward.



The sundial is an instrument that shows the time of day by using the position of the Sun to make a shadow. As you might guess, it works only when the sky is clear.

Most sundials have two main parts: a flat plate, called the dial, and something to cast a shadow on the dial, called the gnomon. The dial has markings that show the time of day. But for a simple sundial like the one we're making, the dial will be the ground.

The earliest sundials date to around 1500 B.C. These ancient instruments, often called shadow clocks, were found in Egypt and Babylon. Around 700 B.C., the Bible's Old Testament describes the "dial of Ahaz." Vitruvius, a Roman author and architect, described sundials around the first century B.C.

Sundials can be works of art. But even if they're simple, they can show how the Sun moves, and they can tell time. Here's how to build the simplest sundial of all. Just make sure the Sun won't be blocked by buildings and trees — no Sun, no sundial!

WHAT! YOU'LL NEED !

☐ A gnomon — something long and straight to cast a shadow (It can be a pencil or something similar; a stick can work, but it has to be really straight.)

☐ A flat area outside where you can set up your sundial and leave it for weeks or months (The flat roof of a building would be a perfect spot.)

☐ Some markers that you can write a number on and that won't blow away (Small, flat rocks work well.)

☐ Modeling clay or Play-Doh

☐ A clock

What to do

1 Find a spot outside where the Sun will shine all day.

2 Go out early one morning after sunrise. Set up your gnomon by sticking it into a lump of Play-Doh or modeling clay. If you don't have any clay, you can stick your gnomon into the ground. Make sure it's in far enough that it can't tip over and that it points straight up. Another way to hold up your gnomon is to use a small flowerpot. Fill it with gravel and stick your gnomon into it.

Be sure your gnomon is tall enough so the shadow goes way over the pot's edge.

3 At the beginning of the next hour (7 o'clock, 8 o'clock, etc.), place a marker at the tip of your gnomon's shadow. Be sure to label your marker with the hour number.

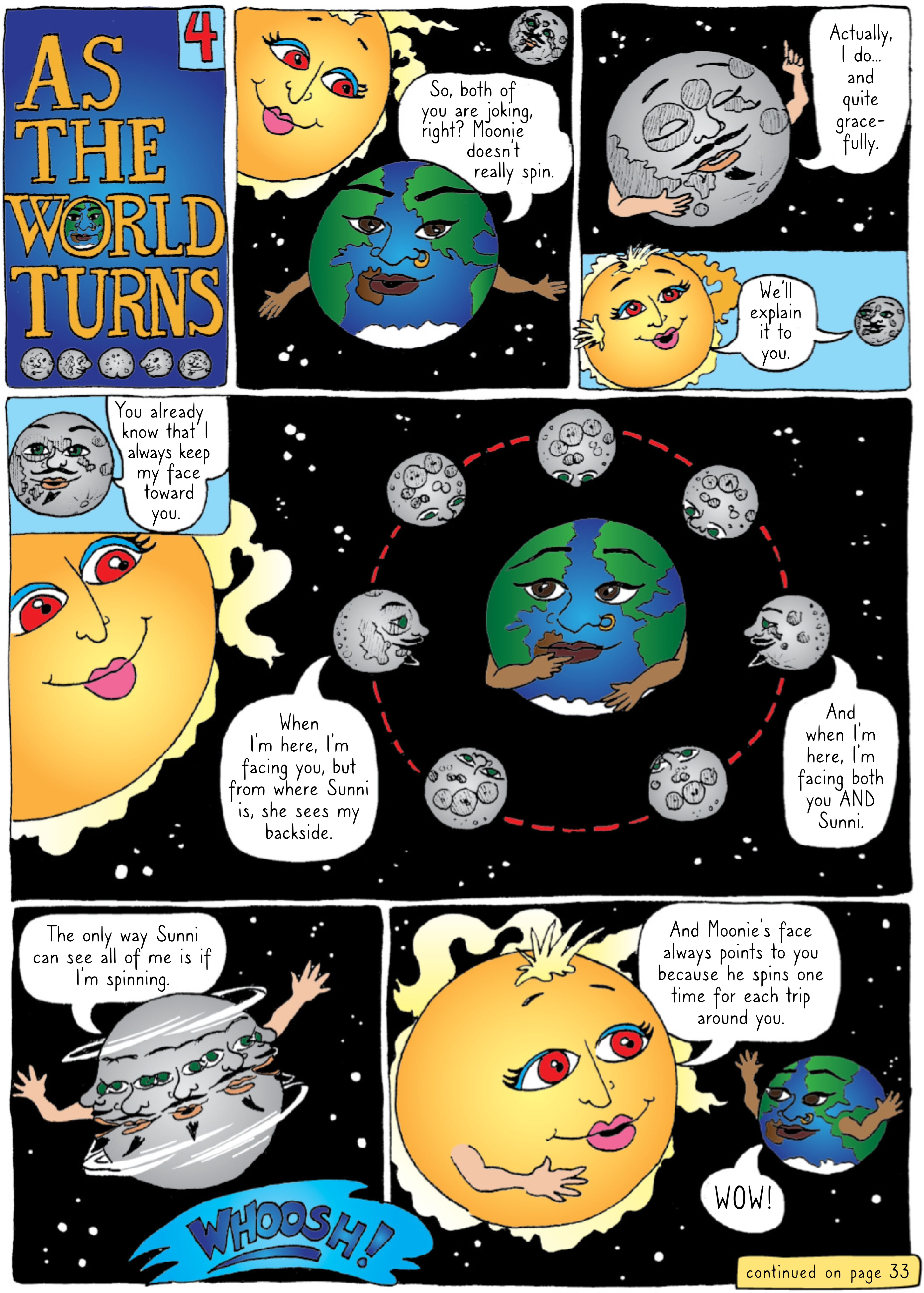
4 Continue to place markers at the start of each hour. If you miss some hours, you can go back the following day and fill them in.

5 Once you have all your markers showing the hours, go back once a week and check your sundial. Is it keeping good time? After a month or two, how much is your sundial's time different from your clock?

Q: Why didn't the Sun go to college?

A: Because it already had thousands of degrees.

SUNDIAL: MARYNA KONOPLYTSKA/DREAMSTIME. MODELING CLAY: GRONDIN FRANCK OLIVIER/DREAMSTIME. ASTRONAUT: DANIELFELA/DREAMSTIME. SUN: ELAELO/DREAMSTIME


AS THE WORLD TURNS
4
So, both of you are joking, right? Moonie doesn't really spin.
Actually, I do... and quite grace-fully.
We'll explain it to you.
You already know that I always keep my face toward you.
When I'm here, I'm facing you, but from where Sunni is, she sees my backside.
And when I'm here, I'm facing both you AND Sunni.
The only way Sunni can see all of me is if I'm spinning.
WHOOSH!
And Moonie's face always points to you because he spins one time for each trip around you.
WOW!

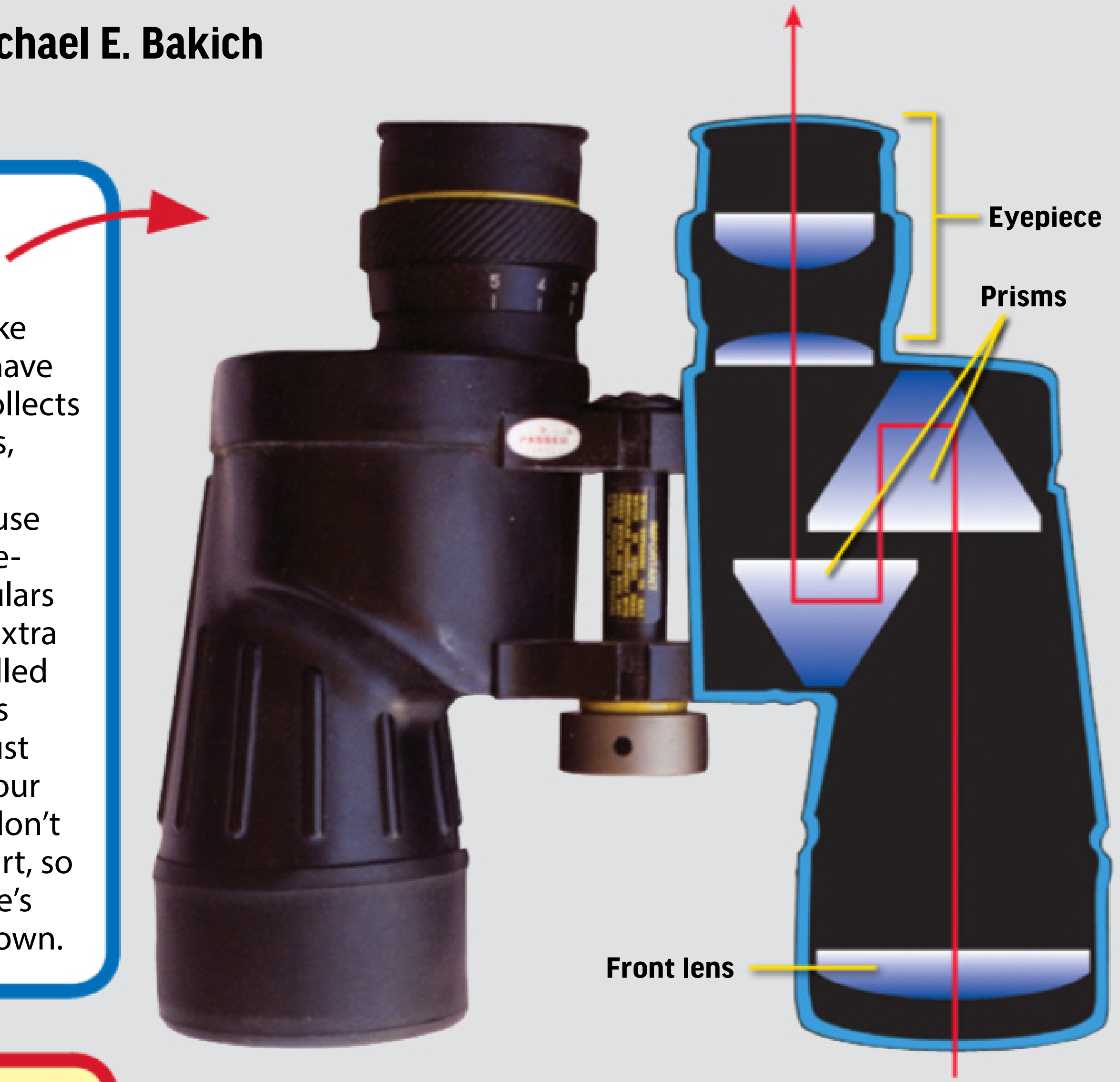
continued on page 33

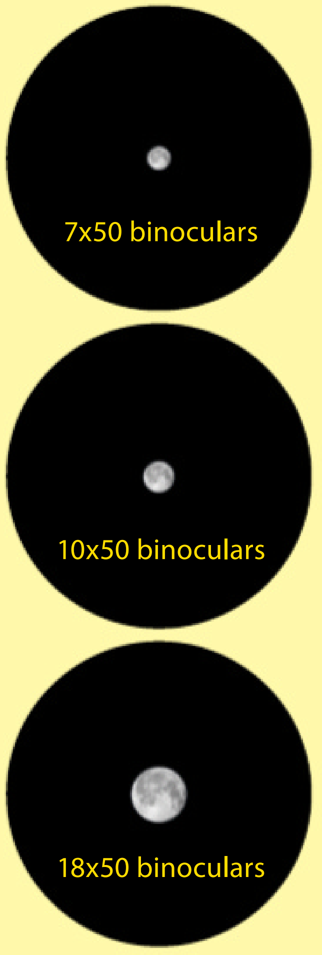
Your first

by Michael E. Bakich

WHAT'S INSIDE

Binoculars work like telescopes: Both have something that collects light. In binoculars, it's the two front lenses. And both use an eyepiece or eyepieces. But binoculars have one or two extra pieces of glass, called prisms, that makes everything look just like it does with your eyes. Telescopes don't have that extra part, so usually a telescope's image is upside down.





Here's how the Moon looks through three different binoculars. JOHN CHUMACK

"I WANT A TELESCOPE. Which one should I buy?" Sometimes, the answer is, "Buy binoculars. Then, if you're still curious, a telescope is next."

But which binoculars are best for looking at things in the sky? And what should you look for when buying them?

Why use binoculars?

- Humans have two eyes, and things look better when you use them both because more light reaches your brain.
- You'll see more details on things you observe.
- You'll see more color on some faint objects.
- Binoculars give you a wide view. You won't see as much as when you use your eyes, but you'll see a lot more than through a telescope.
- Binoculars are easy to carry and set up.
- They're ready to go right out of the box. All binoculars come with a carrying case, neck strap, and lens covers, and most include a lens-cleaning cloth.

When you're ready

Be sure to try the binoculars you're interested in before you buy them. They should bend and focus smoothly and easily. When you look through them, is everything sharp? How do they feel in your hands? Make sure they don't weigh too much. If they're heavy, you won't use them no matter how good they are.

binoculars

WHAT! YOU'LL NEED!

- ☐ A marker
- ☐ Seven sheets of paper
- ☐ Eight rocks
- ☐ Binoculars
- ☐ Two large balls of the same size, such as a soccer ball, basketball, or beach ball
- ☐ A friend

7x35 binoculars should work well for you. 7x50 binoculars will collect more light, but they're also heavier.

You can also talk to others who use binoculars for astronomy. A local club or science center will be a good source of information. Finally, try several models before you pick the one for you.

You can find binoculars at local stores or online. Lots of advertisers in *Astronomy* magazine sell them.

Understanding "power"

Finding out the power (magnification) of your binoculars is easy. Look for two numbers with an "x" between them, like 5x40 or 7x35. The first number is the power of the binoculars. But what does that number really mean?

You can show how power works by doing this simple experiment.

FUN FACTS

7x35 binoculars collect 25 times as much light as your eyes.

7x50 binoculars collect 51 times as much light as your eyes.

What to do

1 Get seven sheets of paper. On each sheet, print one of these numbers: 10, 20, 30, 40, 50, 60, 70. Make the numbers big and bold so that they're easy to read.

2 Head outside to a big open area.

3 Put one of your rocks on the ground. This marker shows your starting point.

4 Walk in a straight line. After 10 big steps, lay the sheet of paper with the number "10" on it on the ground, and put a rock on it so it doesn't blow away. Put one of your balls next to this marker.

5 Walk 10 more steps in the same direction. Put the sheet of paper with "20" on it on the ground, and weight it down with another rock.

6 Do this five more times — for "30," "40," "50," "60," and "70" — until you've used all your papers and rocks. To make sure you walked in a straight line, look from the farthest rock to your starting point. All the rocks and the papers should be in one line.

7 Go back to your starting point.

8 Find the power of your binoculars. If it's 3, hand your friend the second ball, and send her or him out to the "30" marker. If the power is "7," she or he should go all the way out to the "70" marker.

9 Look at the ball your friend is holding through your binoculars.

10 Look at the ball at the "10" marker using just your eyes. Go back and forth, using your binoculars on the far ball and your eyes on the close one. They look the same size!

So, another way to think about power is how many times closer something looks. If your binoculars are 7 power, everything you see through them (not just your ball) will look seven times closer.

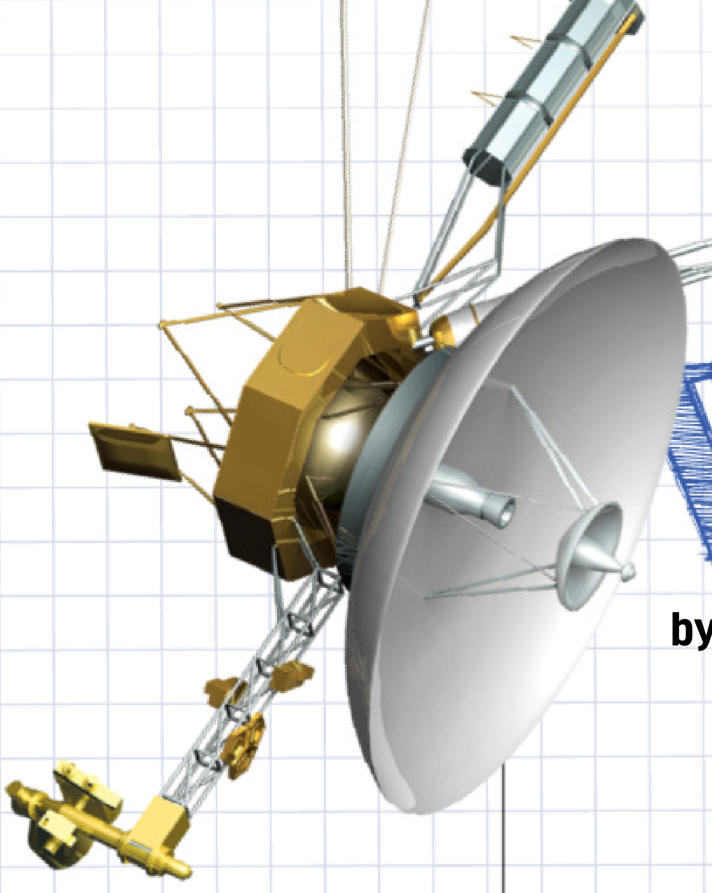
IMPORTANT SAFETY TIP

NEVER look at the Sun through your binoculars!

BINOCULARS: CELESTRON. BINOCULAR ILLUSTRATION: HOLLEY BAKICH. SOCCER BALL: ARA HOVHANNISYAN/DREAMSTIME

A look inside VOYAGER

by Michael E. Bakich



Two Voyager spacecraft launched in 1977. NASA/JPL

The two Voyager spacecraft gave us lots of information about the giant outer planets. Launched in 1977, Voyagers 1 and 2 flew by Jupiter and Saturn, and then Voyager 2 flew by Uranus and Neptune.

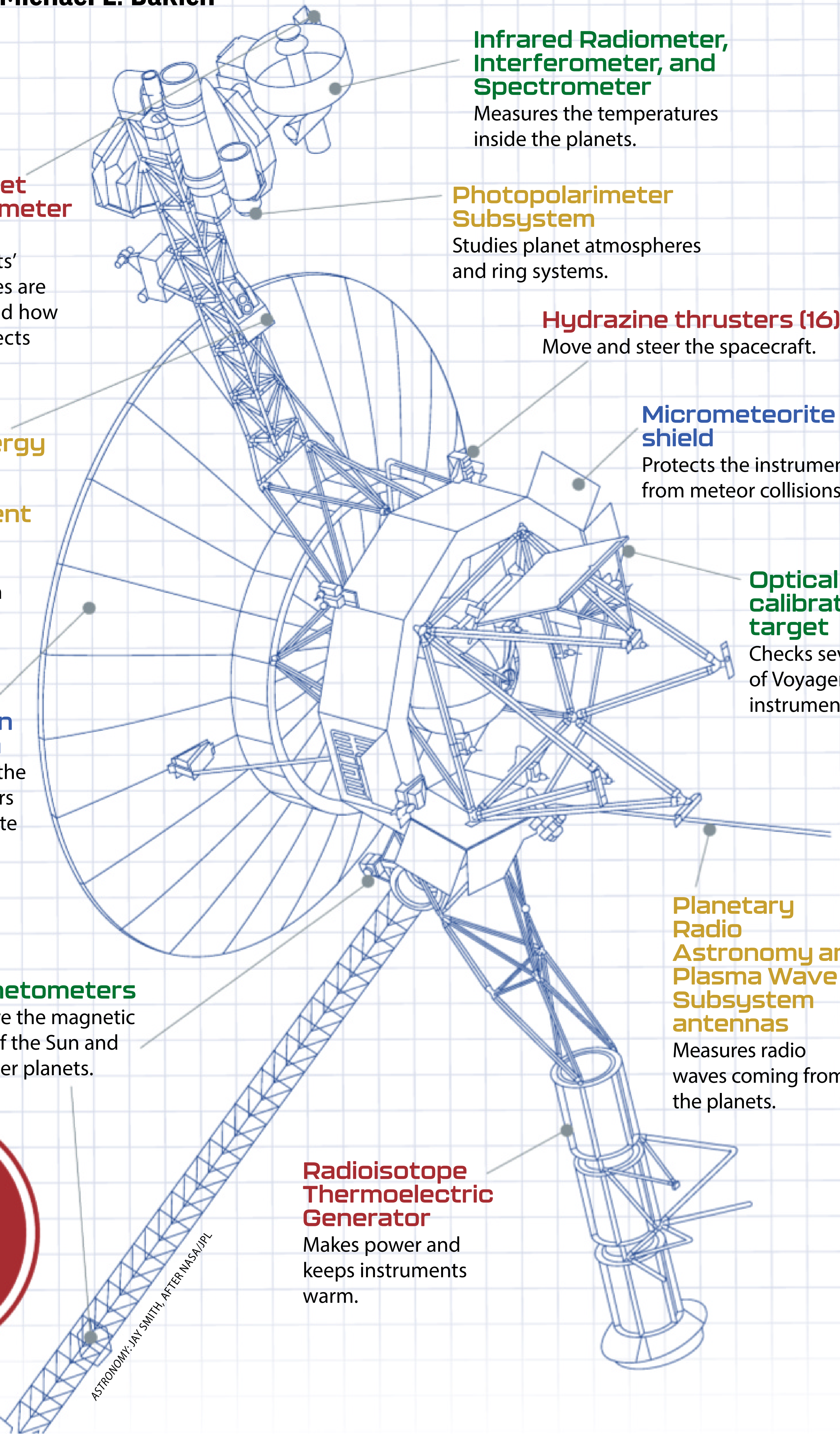
Voyager 1 and 2 flew by Jupiter in 1979. They took close-up pictures of the planet, saw icy cracks on the moon Europa, and even discovered volcanoes on the moon Io.

Two years later, both spacecraft approached Saturn and its amazing rings. After this, Voyager 1 was finished exploring planets and started its journey out of the solar system.

In 1986, Voyager 2 passed only 50,000 miles (80,467 kilometers) from Uranus. It discovered many moons and studied the planet's unusual tilt. Then, in 1989, the spacecraft flew by Neptune, recording amazing images of the planet's weather and discovering more moons. Then it, too, headed toward deep space.

FUN FACT

Voyager 1 is now 13.4 billion miles (21.6 billion km) from Earth.



Infrared Radiometer, Interferometer, and Spectrometer
Measures the temperatures inside the planets.

Ultraviolet Spectrometer
Measures what planets' atmospheres are made of, and how the Sun affects them.

Photopolarimeter Subsystem
Studies planet atmospheres and ring systems.

Hydrazine thrusters (16)
Move and steer the spacecraft.

Micrometeorite shield
Protects the instruments from meteor collisions.

Low-Energy Charged Particle instrument
Measures particles that the Sun sends out.

Optical calibration target
Checks several of Voyager's instruments.

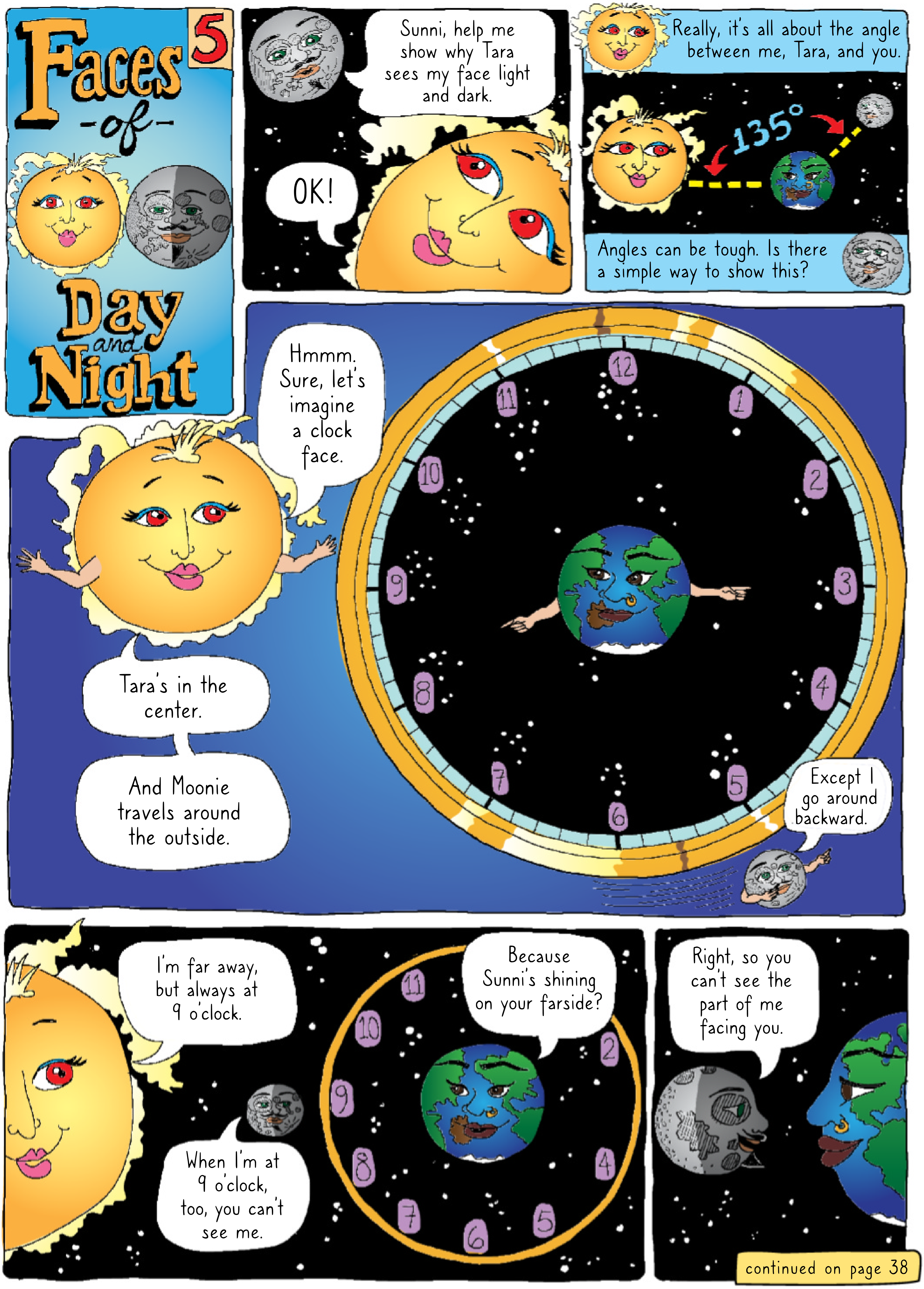
High-Gain Antenna
This is how the two Voyagers communicate with Earth.

Planetary Radio Astronomy and Plasma Wave Subsystem antennas
Measures radio waves coming from the planets.

Magnetometers
Measure the magnetic fields of the Sun and the outer planets.

Radioisotope Thermoelectric Generator
Makes power and keeps instruments warm.

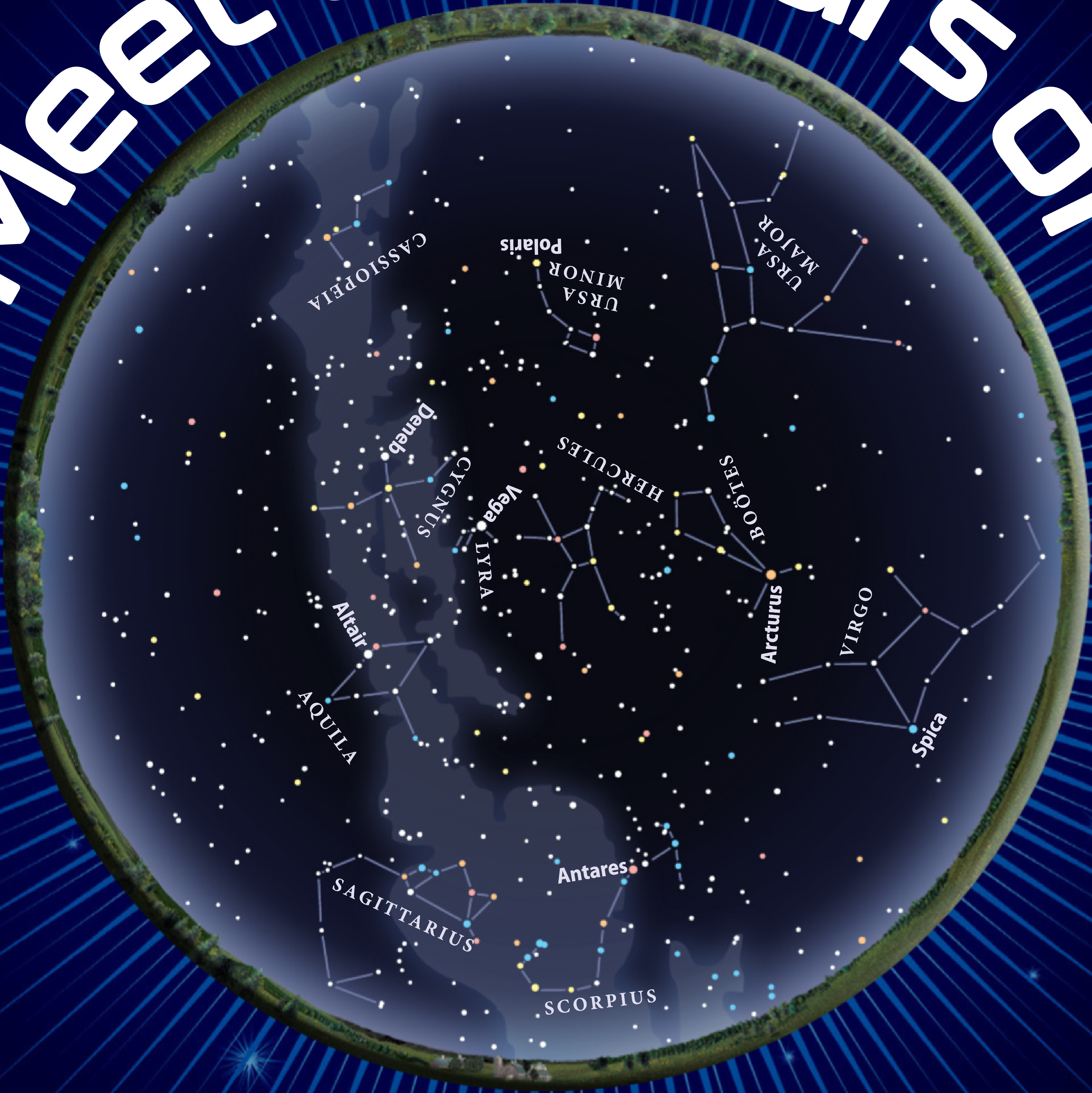
ASTRONOMY: JAY SMITH, AFTER NASA/JPL


Faces -of- Day and Night
5
Sunni, help me show why Tara sees my face light and dark.
OK!
Really, it's all about the angle between me, Tara, and you.
135°
Angles can be tough. Is there a simple way to show this?
Hmmm. Sure, let's imagine a clock face.
12
1
2
3
4
5
6
7
8
9
10
11
Tara's in the center.
And Moonie travels around the outside.
Except I go around backward.
I'm far away, but always at 9 o'clock.
When I'm at 9 o'clock, too, you can't see me.
Because Sunni's shining on your farside?
Right, so you can't see the part of me facing you.

continued on page 38

Meet the stars of SUMMER

by Raymond Shubinski


CASSIOPEIA
Polaris
URSA MINOR
URSA MAJOR
Deneb
CYGNUS
HERCULES
BOÖTES
Vega
LYRA
Altair
AQUILA
Arcturus
VIRGO
Spica
Antares
SAGITTARIUS
SCORPIUS

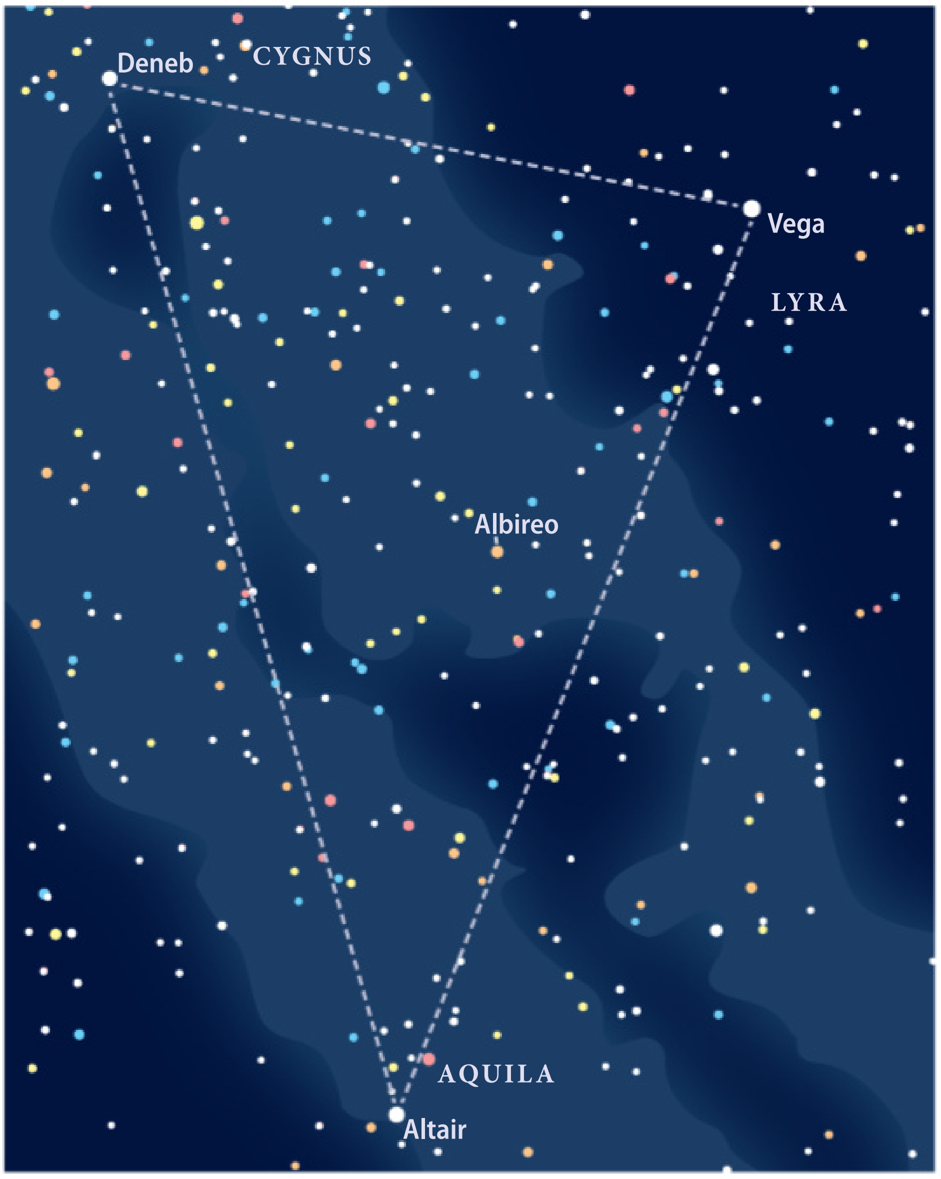
SUMMER IS A GREAT time to look at the stars. The air is warm and it's easier to stay up late when you don't have to go to school. Head out about an hour or so after sunset, and remember, the darker your spot, the better. So, pick a night when the Moon's not too bright. You'll be amazed at how much you can see in the summer sky.

Start by looking for the Big Dipper. It's part of the constellation Ursa Major the Great Bear. In the spring, the Big Dipper was high in the sky, but now it's low in the northwest. As Earth goes around the Sun, our view of the night sky each season changes. The constellations have the same shapes, but their places in the sky are different.

Find the three stars that make the Big Dipper's handle, and then find the four stars that make its bowl. Draw a line through the two stars at the end of the bowl, and follow them in the direction the bowl opens until you find Polaris, the North Star. The two Pointer stars will always point to Polaris, no matter what the season.

High in the sky, the three bright stars known as the Summer Triangle are easy to find. Vega in Lyra, Deneb in Cygnus, and Altair in Aquila lie near the starry path of the Milky Way. Follow the Milky Way south from Aquila, and you'll find the constellation Sagittarius the Archer. Just west of Sagittarius is Scorpius the Scorpion, which contains the red supergiant star Antares. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

Polaris is the star at the end of the handle of the Little Dipper. It's medium-bright, but still the brightest star in the constellation Ursa Minor the Bear Cub. It's not the brightest star in the sky, but it is famous because it doesn't seem to move. (See p. 21.)



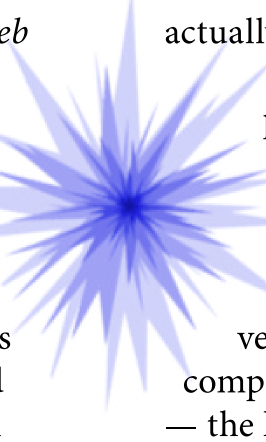
The Summer Triangle is easy to see high overhead in the summer. This diagram shows east at the bottom and north to the left. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

The Bear Cub is hard to picture. But if you're far from city lights, the Little Dipper isn't too hard to pick out.

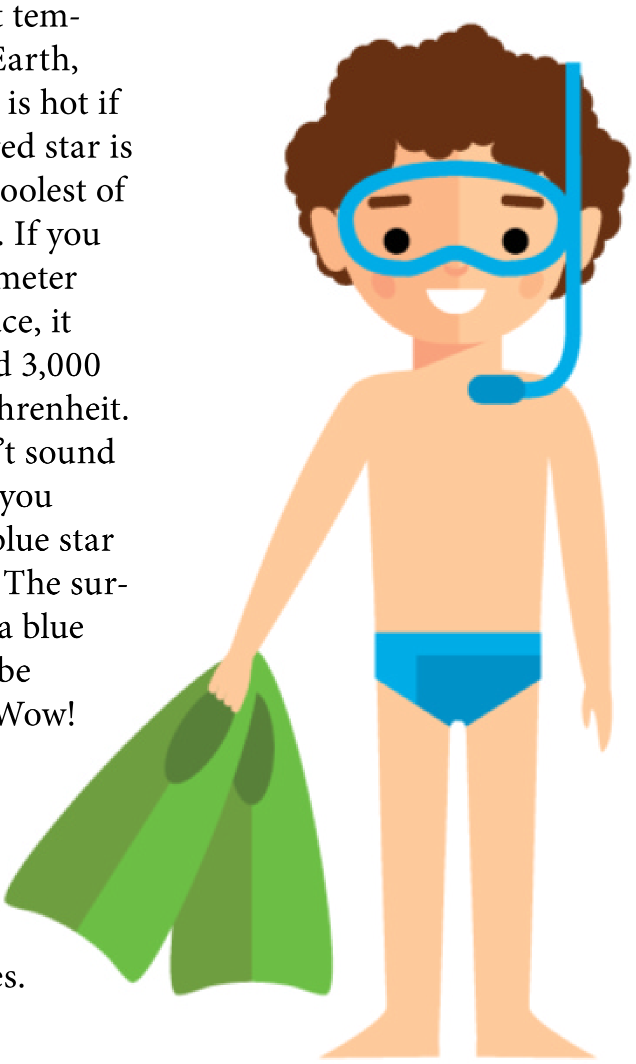
When you're done looking at the bears, turn to the east and look about halfway up to see the three bright stars that make the Summer Triangle. The Summer Triangle is not a constellation. Rather, it's an easy-to-find star picture that astronomers call an asterism. Think of an asterism as an unofficial constellation.

This asterism is made from the three brightest stars from three different constellations. The stars are Deneb, Vega, and Altair. The star highest in the triangle is Deneb. The word *Deneb* means "tail," and this star is the tail of Cygnus the Swan. If you're at a dark place, you can see the swan flying along the Milky Way with its wings spread out. And on the other side from Deneb, a beautiful star called Albireo is the Swan's head.

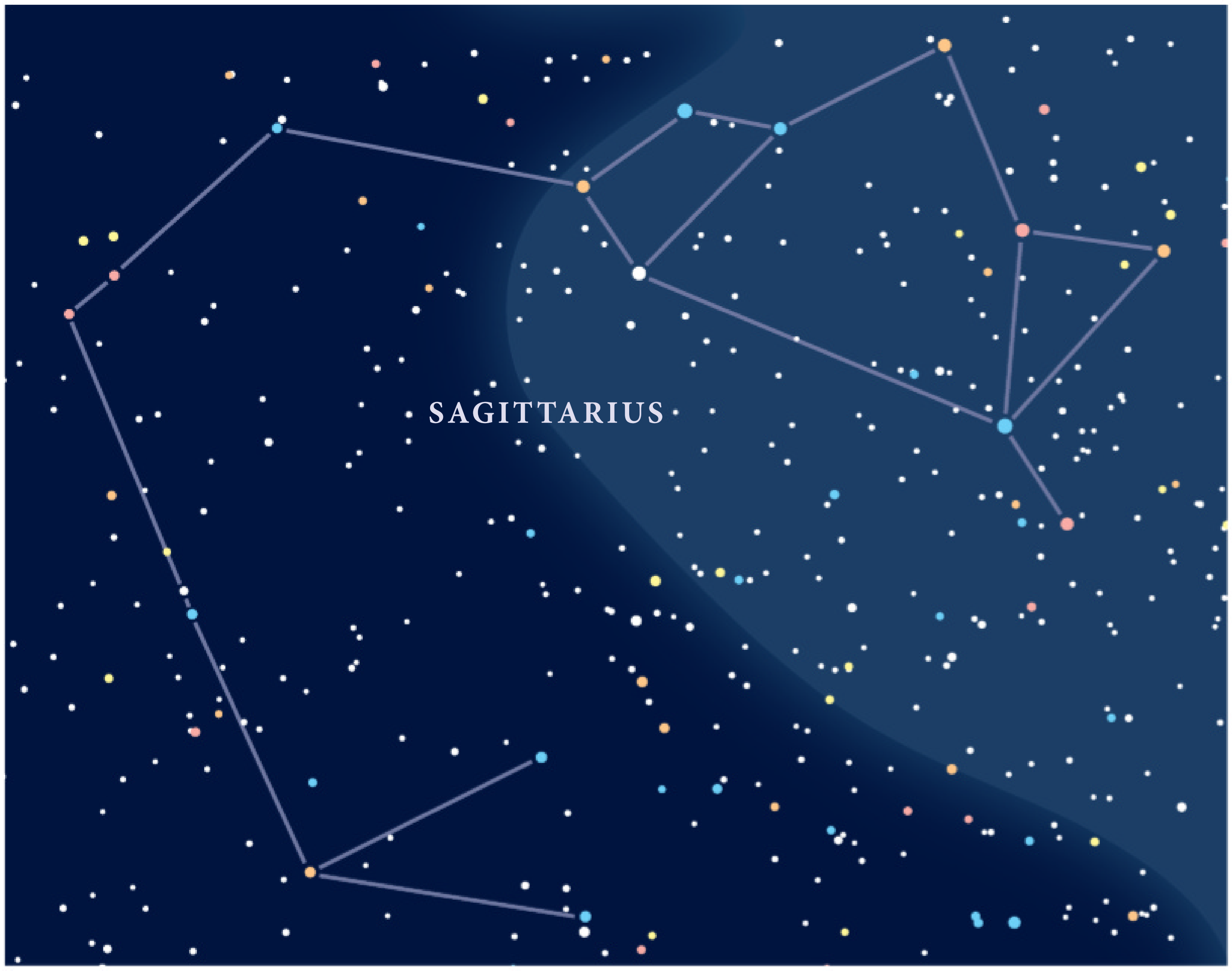
Another way people look at Cygnus is as the Northern Cross. Deneb is the top of the cross, the swan's wings are the crossbar, and Albireo is the bottom. If you look at that star through a telescope (any size), you'll see that it's actually two stars. The brighter one is golden, while the fainter star is blue.



Stars have different colors because they're shining, or burning, at different temperatures. Here on Earth, we think something is hot if it's "red hot." But a red star is actually one of the coolest of all the stars. If you put a thermometer on its surface, it would read 3,000 degrees Fahrenheit. That doesn't sound very cool until you compare it with a blue star — the hottest of all. The surface temperature of a blue star like Deneb can be 50,000 F or higher. Wow! Our Sun is a white star. Its temperature is 11,000 F, so it's hotter than red stars but a lot cooler than blue ones. That means it's just right for us.



OPPOSITE PAGE BACKGROUND: NATALIA KUCHUMOVA/DREAMSTIME. STARBURST: ILLIA HRYHOREV/DREAMSTIME. CHILDREN: ANNA VITEEVA/DREAMSTIME



The constellation Sagittarius the Archer is low in the sky for most people who live in the United States. The easiest part to see is the Teapot, which is at the upper right.

ASTRONOMY: RICHARD TALCOTT AND ROEN KELLY

To the right of Deneb is an even brighter star, Vega. It's in the constellation Lyra the Harp. Vega is the fifth-brightest star in the sky, and it shines blue-white. Lyra is a small constellation. Along with Vega, it mainly has four stars that look like a crooked rectangle. According to legend, Lyra is the harp once played by a musician named Orpheus whose music could charm even rocks and trees. When Orpheus died, the gods put his famous instrument in the sky.

Altair, at the bottom of the Summer Triangle, is the brightest star in the constellation Aquila, the war eagle of Zeus. Look carefully and you might see the shape of a bird in these stars.

Look below Altair toward the south to find the constellation Sagittarius the Archer. This archer is a centaur — a mythological creature who is half-man and half-horse. If you can't see a centaur, you're not alone. But don't worry: Instead, try looking for the shape of a teapot in the stars of Sagittarius. It's easy to find a pot with a pointed lid, a handle, and a spout.

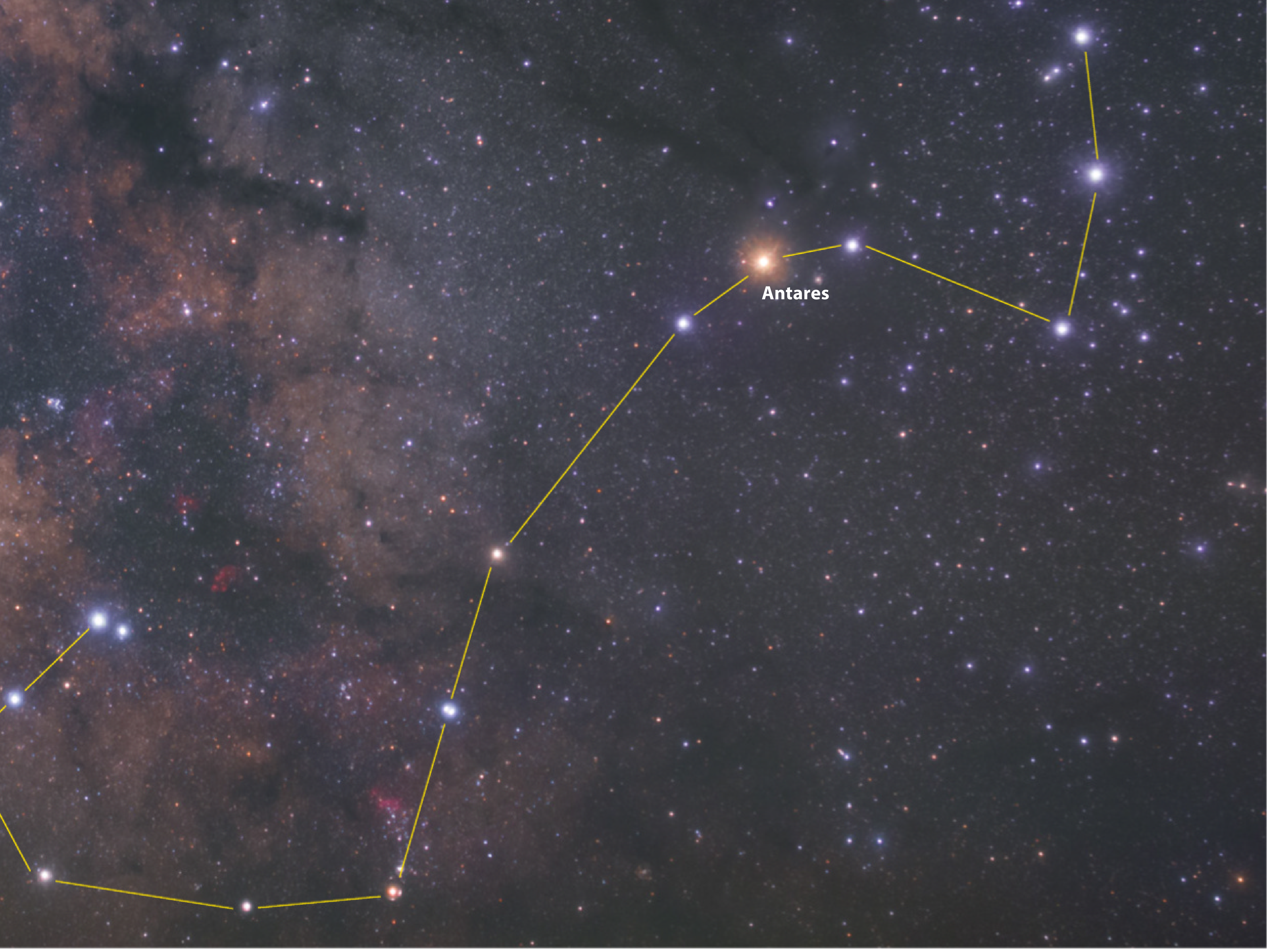
If it's dark enough where you're looking from, you may also see the Milky Way rising like steam from the spout of the teapot. But it's not steam — when you look at the Milky Way, you are seeing millions of stars that are part of our home galaxy. These stars are much farther away than the ones we see as points of light. So, we wouldn't normally see them. But because there are so many of them, their light blends together, and it looks like someone spilled milk across the sky.

FUN FACT

Some people pronounce Boötes like the word "boots," but that's not right. Each letter O gets its own sound, the sound of the "oh" in "snow." So, the constellation's name is pronounced Boh-OH-teez.

Sagittarius is holding a bow and arrow. He's about to shoot Scorpius the Scorpion, the constellation to the right of Sagittarius. The arrow is pointed at the scorpion's heart, a bright red star named Antares.

This is a large constellation, and it's easy to imagine a scorpion here. Above Antares are the stars that represent the body and claws. Below the scorpion's heart is the long tail and deadly stinger. In Hawaii, this constellation is called the Hook of Maui. According to one story, Maui was a demigod who pulled



Scorpius really does look like a scorpion. The brightest star is Antares, which is its heart. From there, trace the winding tail down to the left and back up. It ends with two stars that mark the stinger. The three stars to the right of Antares are the scorpion's body. TONY HALLAS

the Hawaiian Islands out of the ocean using this hook.

High in the sky to the west of Vega is Hercules the Hero, the great strongman of legend. This constellation doesn't have any really bright stars, but it's not too hard to find. The four brightest ones form a shape that looks like a wastebasket. Astronomers call it the Keystone, and it marks Hercules' body. The stars of his arms and legs attach to it but are faint and hard to see. In mythology, Hercules had many adventures and fought many battles. Once he even fought Leo the Lion, a constellation of spring that has set in the west.

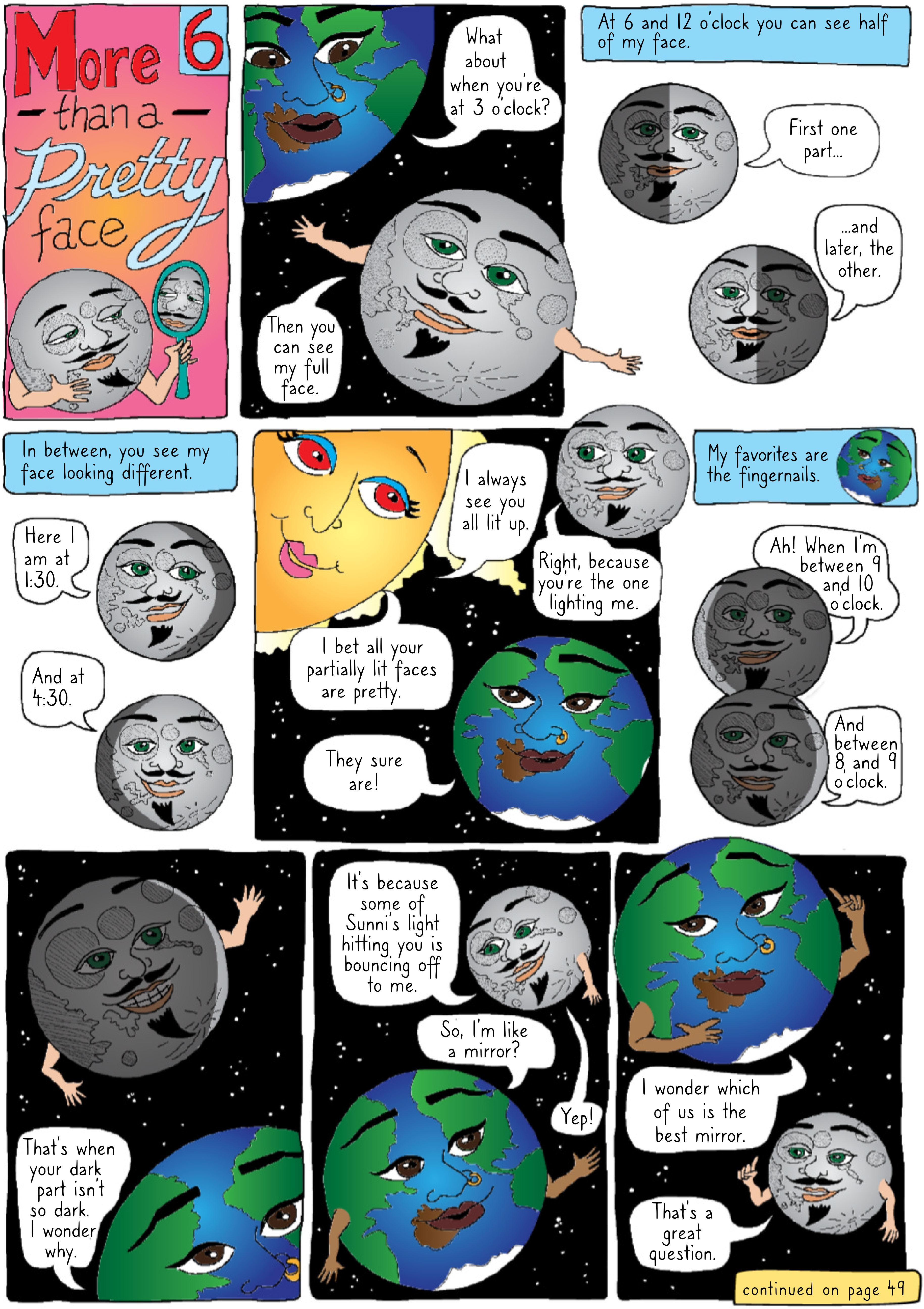
Near Hercules is Boötes, a constellation we saw rising in the spring sky. Its brightest star, Arcturus, is now shining high in the west as Boötes still chases Ursa Major through the sky. A star picture of a man chasing a bear is hard to see, so instead look for a kite. Arcturus is at the tail of the kite; farther up are two stars that make the crosspiece, and one star is at the kite's tip.

Between Hercules and Boötes is a beautiful little constellation called Corona Borealis the Northern Crown. This star group is shaped like a cup or bowl. It represents the crown of the princess Ariadne. She fell in love with Theseus, who had come from the Greek city of Athens to kill a half-man, half-bull monster called the Minotaur. Ariadne gave Theseus a ball of string to help him find his way out of the labyrinth where the Minotaur lived. Her crown was put in the sky by the gods, so people would remember her.

As summer goes on, these constellations will move west until new ones rise in the east. These new stars and constellations announce the start of a new season, fall.

More than a Pretty face

6

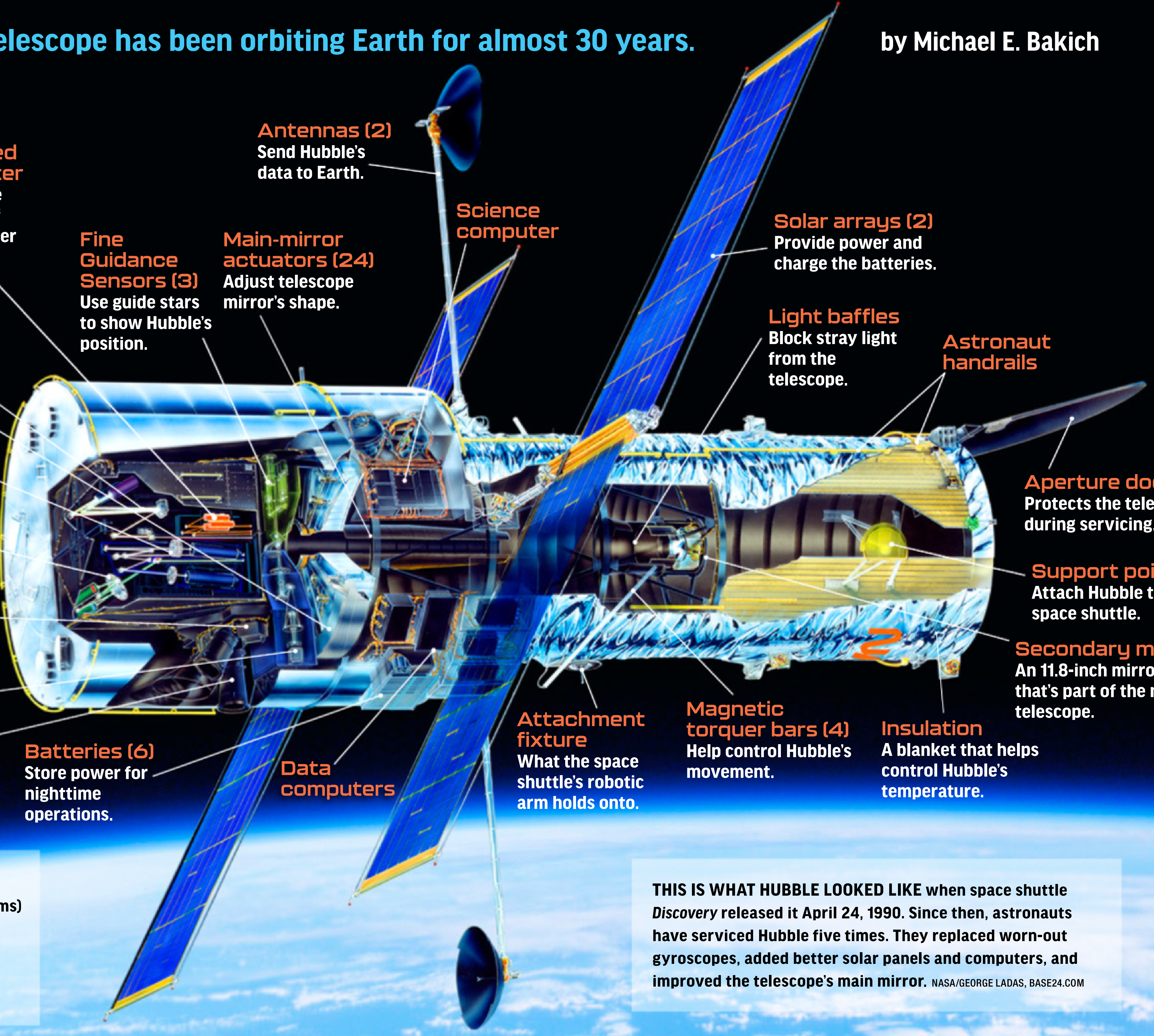

What about when you're at 3 o'clock?
Then you can see my full face.
At 6 and 12 o'clock you can see half of my face.
First one part...
...and later, the other.
In between, you see my face looking different.
Here I am at 1:30.
And at 4:30.
I always see you all lit up.
Right, because you're the one lighting me.
I bet all your partially lit faces are pretty.
They sure are!
My favorites are the fingernails.
Ah! When I'm between 9 and 10 o'clock.
And between 8 and 9 o'clock.
That's when your dark part isn't so dark. I wonder why.
It's because some of Sunni's light hitting you is bouncing off to me.
So, I'm like a mirror?
Yep!
I wonder which of us is the best mirror.
That's a great question.

continued on page 49

A look inside Hubble

The Hubble Space Telescope has been orbiting Earth for almost 30 years.

by Michael E. Bakich



Imaging Spectrograph
Analyzes the light from deep-sky objects.

High-Speed Photometer
Measures the brightness of stars and other objects.

Main mirror
Collects light from sky objects.

Faint Object Camera
Photographs dim objects.

Faint Object Spectrograph
Studies light from dim objects.

Gyroscopes (3)
Provide a reference that points Hubble.

Wide Field Planetary Camera
Hubble's main picture taker.

Star trackers (3)
Help tell Hubble how high it is flying.

Fine Guidance Sensors (3)
Use guide stars to show Hubble's position.

Main-mirror actuators (24)
Adjust telescope mirror's shape.

Antennas (2)
Send Hubble's data to Earth.

Science computer

Batteries (6)
Store power for nighttime operations.

Data computers

Solar arrays (2)
Provide power and charge the batteries.

Light baffles
Block stray light from the telescope.

Astronaut handrails

Aperture door
Protects the telescope during servicing.

Support points
Attach Hubble to a space shuttle.

Secondary mirror
An 11.8-inch mirror that's part of the main telescope.

Attachment fixture
What the space shuttle's robotic arm holds onto.

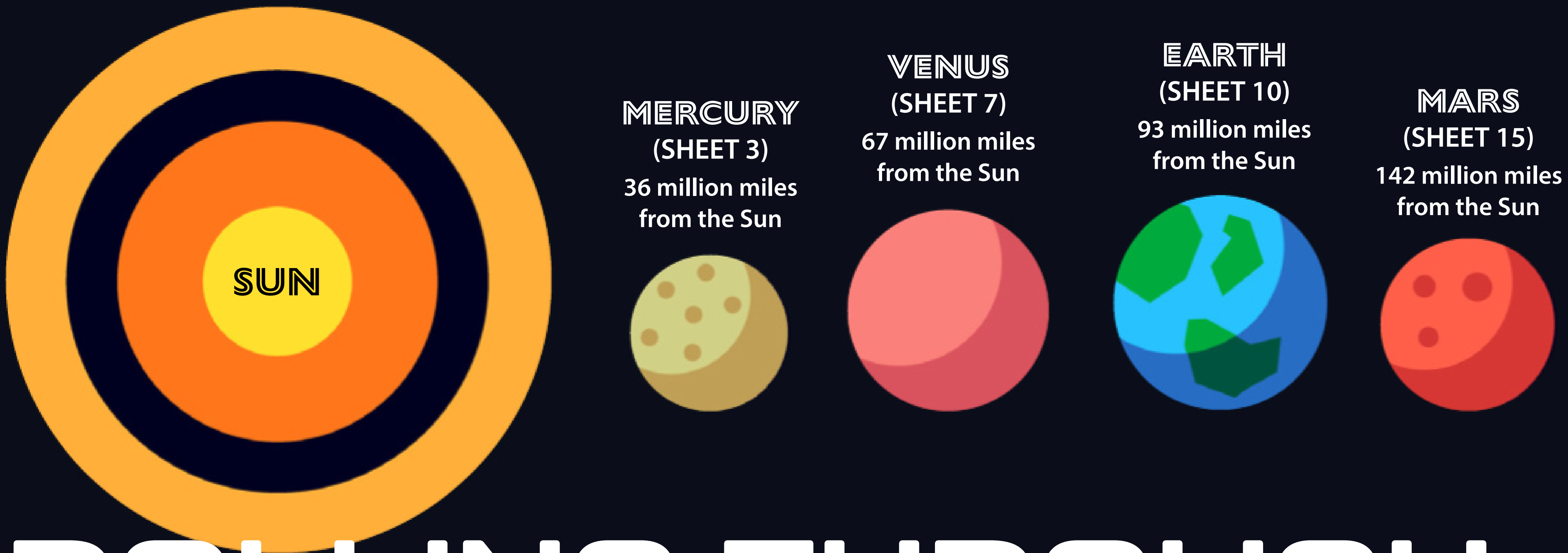
Magnetic torquer bars (4)
Help control Hubble's movement.

Insulation
A blanket that helps control Hubble's temperature.

VITAL STATISTICS

Mass: 24,500 pounds (11,110 kilograms)
Length: 43.5 feet (13.2 meters)
Width: 13.8 feet (4.2 m)
Optical design: Reflector
Main mirror: 94 inches (2.4 m)

THIS IS WHAT HUBBLE LOOKED LIKE when space shuttle *Discovery* released it April 24, 1990. Since then, astronauts have serviced Hubble five times. They replaced worn-out gyroscopes, added better solar panels and computers, and improved the telescope's main mirror. NASA/GEORGE LADAS, BASE24.COM


SUN
MERCURY
(SHEET 3)
36 million miles from the Sun
VENUS
(SHEET 7)
67 million miles from the Sun
EARTH
(SHEET 10)
93 million miles from the Sun
MARS
(SHEET 15)
142 million miles from the Sun

ROLLING THROUGH

by Michael E. Bakich

WHAT! YOU'LL NEED

☐ A roll of toilet paper with at least 400 sheets
(If your roll has less than 400 sheets, start a second roll where the first one runs out.)

☐ Eight to 16 small markers — something as simple as small stones, coins, or marbles, or something made of paper that you could label with planet names

☐ A big hallway
(It needs to be 114 feet long if you're showing the planets just out to Neptune. It will have to be 150 feet long if you will be including Pluto.)

The planets of our solar system aren't all the same distance from the Sun. This activity will help you picture how far they are from the Sun, and also how much closer or farther they are from it than Earth. The first number for each planet shows its average distance. Venus and Earth don't change their distances to the Sun much. For the other planets, under the main number, you'll find the closest and farthest distances of that planet from the Sun.

FUN FACT
At this scale, the length of each sheet of toilet paper equals 9.3 million miles (15 million kilometers).

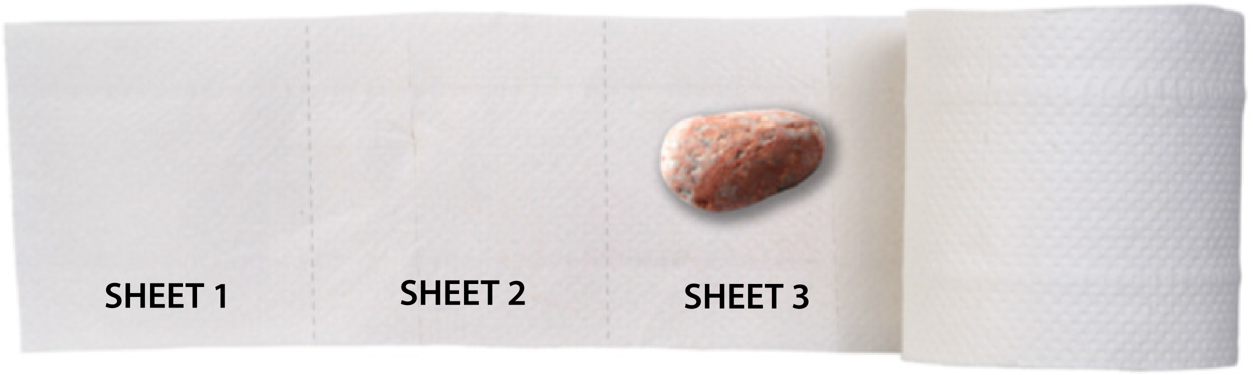
WHAT TO DO

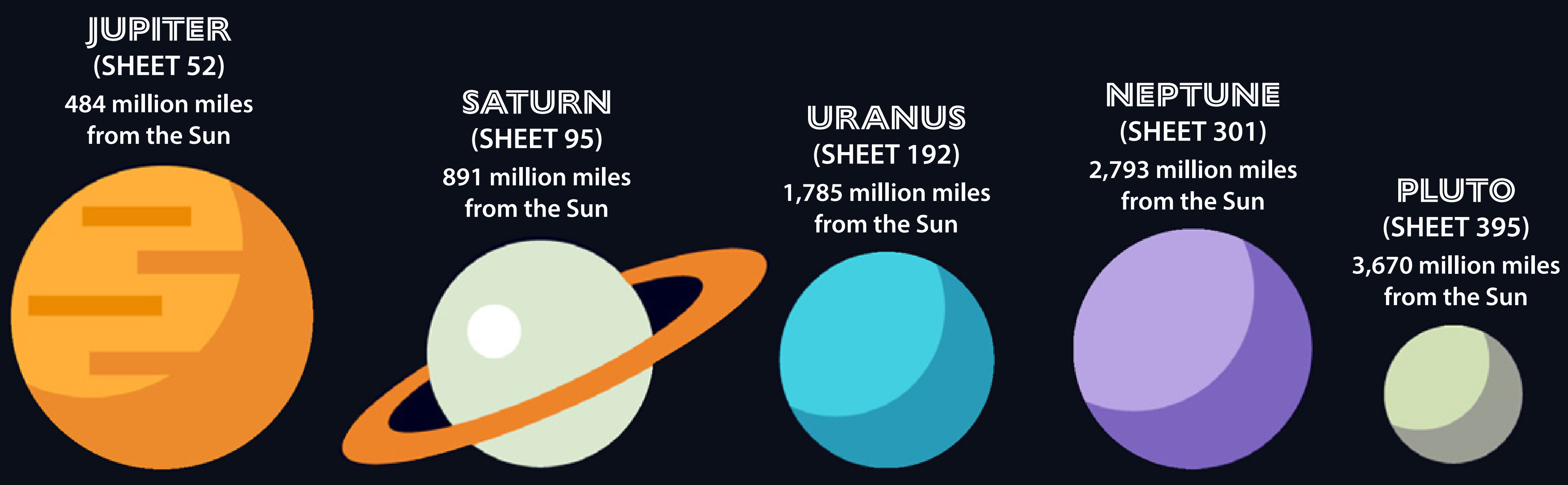
Start at a wall. You can label the wall "The Sun," and even tape a picture of the Sun to it. Then begin unrolling the toilet paper so that the first sheet touches the Sun wall. Carefully count the sheets as you unroll the paper in a straight line, starting at the wall with Number 1. You might want to label every 10th sheet. Then do the following:

MERCURY

Place a mark at the center of sheet 3.

Optional: If you want to show Mercury's range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 3 and a "far" one halfway through sheet 4.


SHEET 1
SHEET 2
SHEET 3



JUPITER
(SHEET 52)
484 million miles from the Sun

SATURN
(SHEET 95)
891 million miles from the Sun

URANUS
(SHEET 192)
1,785 million miles from the Sun

NEPTUNE
(SHEET 301)
2,793 million miles from the Sun

PLUTO
(SHEET 395)
3,670 million miles from the Sun

THE SOLAR SYSTEM

SOLAR SYSTEM: TASTYVECTOR/DREAMSTIME. STACKED STONES: SPAXIA/DREAMSTIME. STONE: ANNIE SU YEK YEK/DREAMSTIME. TOILET PAPER (LEFT): BOJAN PAVLUKOVIC/DREAMSTIME. ALIEN: DANIELFELA/DREAMSTIME

VENUS

Place a mark at the center of sheet 7.

EARTH

Place a mark at the start of sheet 10.

MARS

Place a mark at the center of sheet 15.

Optional: If you want to show Mars' range (from its nearest to its farthest points from the Sun), place a "near" marker at a beginning of sheet 14 and the "far" one at the start of sheet 16.

JUPITER

Place a mark at the center of sheet 52.

Optional: If you want to show Jupiter's range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 50 and a "far" one at the start of sheet 55.

SATURN

Place a mark at the center of sheet 95.

Optional: If you want to show Saturn's range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 90 and a "far" one at the start of sheet 101.

URANUS

Place a mark at the start of sheet 192.

Optional: If you want to show Uranus' range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 183 and a "far" one at the start of sheet 201.

NEPTUNE

Place a mark at the start of sheet 301.

Optional: If you want to show Neptune's range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 298 and a "far" one at the start of sheet 303.

In 2006, the International Astronomical Union reclassified Pluto, so it's not a planet anymore. Many people, however, still include it in models of the solar system. If you choose to include Pluto, do the following:

PLUTO

Place a mark at the center of sheet 395.

Optional: Pluto's distance changes a lot during its trip around the Sun. If you want to show its range (from its nearest to its farthest points from the Sun), place a "near" marker at the beginning of sheet 296 and a "far" one at the start of sheet 503.

QUESTIONS

1. Which planets are closest to each other?
2. Which two are farthest apart?
3. Which planet is closest to Earth?
4. Which planet do you think is hottest? Coldest?
5. Which planet has the greatest distance range?

TOILET PAPER (ABOVE): BRANDON BLINKENBERG/WIKIMEDIA COMMONS

Q: How do the planets hold up their pants?
A: With the asteroid belt!

HOW TELESCOPES WORK

by Michael E. Bakich

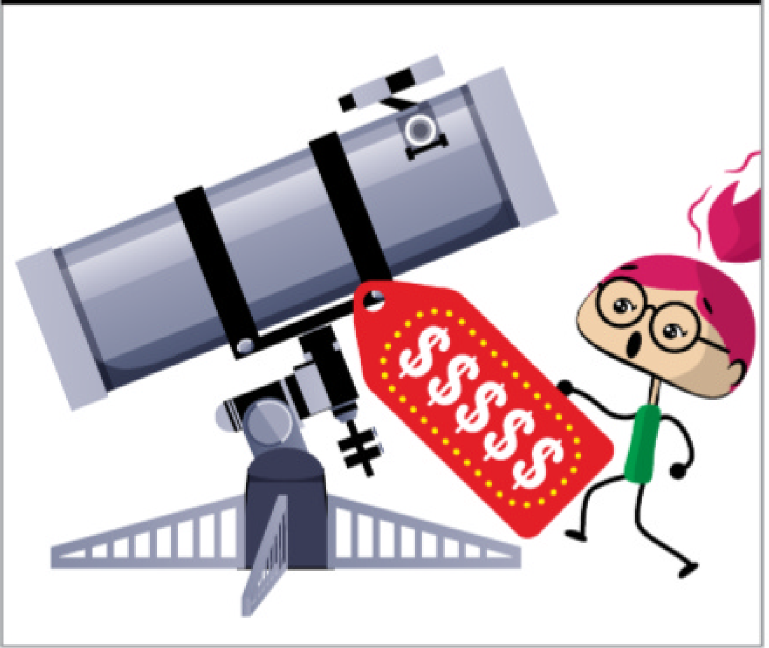
You've decided you want a telescope. That's great! But now comes the hard part: choosing a telescope that's right for you, one that you'll use and enjoy.

Get real

There are several different kinds of telescopes with many different features and price tags. You can easily spend a few thousand dollars on a telescope.

But let's get real. Most families don't have that kind of money lying around the house. So, you'll probably be looking at telescopes that cost a few hundred dollars. That's OK. If your interest in astronomy goes on for years, you can always buy a bigger scope. And you want to make sure you get the most for your money.

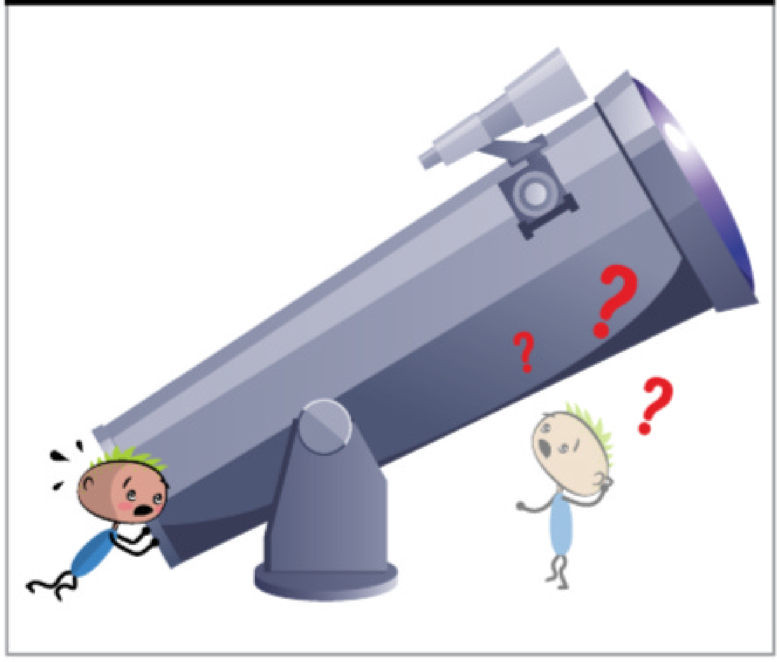
STICKER SHOCK



You don't have to start out by buying an expensive telescope. You can see a lot through smaller, less expensive ones.

MARZANNA SYNCERZ/DREAMSTIME

IS IT TOO BIG?



ALL ILLUSTRATIONS: *ASTRONOMY*: KELLIE JAEGER

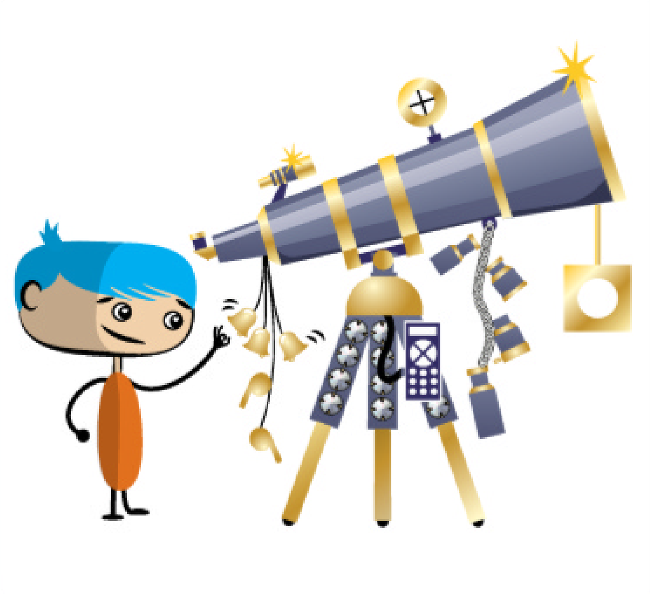
Big telescopes are heavy, and some are tough to move from one place to another. You might even need a ladder to use one.

Get smart

Before you can choose a telescope, you have to know what you're talking about. A telescope's job is to collect light and gather it all up at a point called the focus so we can look at it. There are three types of telescopes, and they all do that. But which one is best for you?

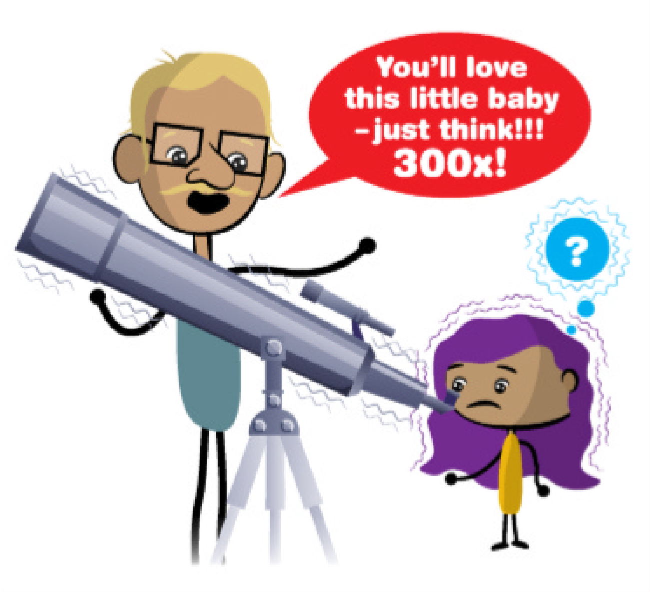
The first type uses a lens to collect light. It's called a refractor. These telescopes are best for looking at bright objects like the Moon, the planets, and double stars (which look like just one star until you point a

TOO MANY PARTS



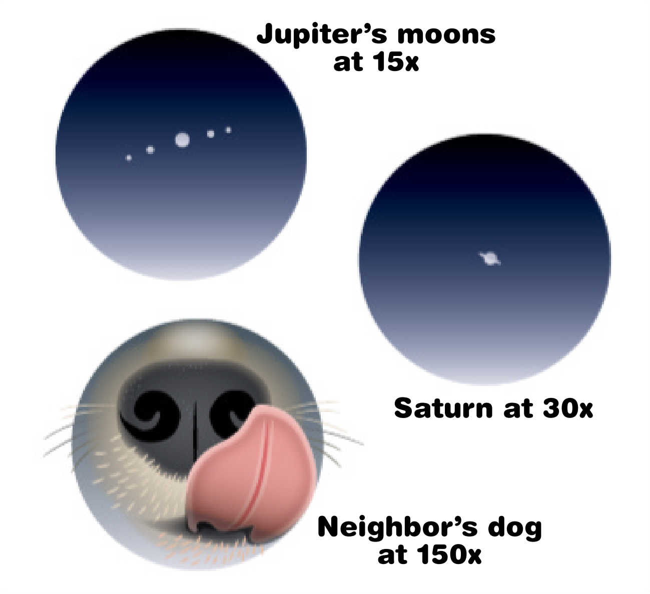
When you choose your telescope, don't worry about adding all the extras to it. Those can come later.

HIGH POWER ISN'T IMPORTANT


You'll love this little baby –just think!!! 300x!
?

You don't need high magnification to have a great time under the stars. Sometimes, less is better.

PICK THE RIGHT MAGNIFICATION



High magnification really shrinks how much you can see. Start with low powers, and then move up.

telescope at them). One good thing about refractors is that you don't have to adjust the lens.

The second type of telescope uses a mirror to collect light. Because mirrors reflect light, this type is called a reflector. Reflectors are less expensive than refractors because it's easier (and cheaper) to make a mirror than a lens. So, for the same money, you can buy a bigger reflector than refractor.

The third type of telescope uses a lens and a mirror to collect light. It's called a compound telescope. Because of the lens, these telescopes can be a lot shorter than a reflector.

Because they're bigger than refractors, reflectors and compound telescopes are better if you want to look at fainter objects, like galaxies.

What size?

When people talk about a telescope's "size," they mean its aperture. Aperture is the size of the telescope's main lens or mirror. So, a 4-inch reflector isn't 4 inches long. Instead, its main mirror is 4 inches in diameter.

Remember, a telescope's job is to collect light. The larger the telescope's aperture, the more light it collects. A bigger aperture also gives sharper images.

So, look for the largest-aperture telescope you can afford. A refractor for beginners should have an aperture around 2½ inches. A beginner's reflector should have at least a 4-inch aperture.

If you can't find the aperture on the telescope or its box, ask.

More than anything else, aperture determines what you'll be able to see through your telescope.

What to avoid

First, avoid the gizmo trap. Let's say you're looking at two telescopes, and both cost $150. Telescope 1 comes with a finder scope and one eyepiece. Telescope 2 comes with a finder scope, four eyepieces, a Barlow lens, a Sun filter, a Moon filter, and an image erector.

Telescope 2 is the better deal, right? Not necessarily! All those gizmos cost money. This means that less money went into making the actual telescope itself, and its mount. So, Telescope 1 is probably a better one with a sturdier mount.

If you're just starting out, you don't need a lot of extras — some are confusing and hard to use. When you're looking for your first telescope, here's a good rule to follow: Less is more.

The second thing to avoid is the power trap. The first question most

WATCH OUT FOR THE WOBBLIES

No matter which kind of telescope you choose, make sure it is attached to a sturdy mount. Stay away from telescopes mounted on long, skinny legs held together with tiny screws. Nothing is worse than trying to use a telescope that wobbles every time a small breeze blows.

IMPORTANT SAFETY TIP

Never point your telescope, or anything else you can look through, at the Sun — and that includes your eyes. Never look directly at the Sun! It's so bright that it can boil the liquid in your eyes. Yuck! That will give you problems for your whole life. You could even go blind. There are solar filters that make looking at the Sun safe. If you're going to look through a telescope with a solar filter on it, be sure the person who owns it knows what they're doing.

Solar filter

people ask about a telescope is, “How much does it magnify?”

Telescope manufacturers know this, which is why some of them put stuff like this on their boxes: “MAGNIFIES 300 TIMES!!!”

Well, surprise! A telescope by itself doesn’t make things look bigger, it makes them look brighter. Making things look bigger is the job of the eyepieces you use with the telescope. By changing eyepieces, you change the power (another word for magnification).

Eyepieces have numbers marked on them. The lower the number on the eyepiece, the higher power it gives. And, believe it or not, you don’t need a lot of magnification. You can see Jupiter’s four biggest moons through an eyepiece that gives 15 times power. (Sometimes you’ll see this written as 15x.) Saturn’s rings pop into view at about 30x.

Most beginner telescopes won’t give you a good image at any power over 100x. So, it’s a waste to magnify something 300 times. What you see will be big, all right, but it will look terrible.

It’s nice to have a couple of eyepieces for your telescope. If you can, pick one that gives low power (around 15x) and one that gives medium power (between 30x and 60x).

The third and final thing to avoid is the “long and skinny” trap. Most people think that a telescope should be long and skinny, just like the earliest ones. And there are good telescopes that look like that. But there are also some great telescopes that look short and fat.

Get a scope!

Where should you get your telescope? One of the best places is at a store that specializes in them. The clerks will be able to help you choose a good one, and you can test the telescope right in the store. You’ll also be able to take it back if something needs repairing. And the store probably will carry eyepieces and other things you might want to buy later on.

Unfortunately, there aren’t many telescope stores, and the closest one to you might be far away. Of course, many department stores, camera shops, and toy stores sell telescopes. But you’ll have to be careful. Chances are that no one in the store will know anything about telescopes. So, they won’t be able to help you if you have any questions.

Many people buy their telescopes through the internet. First, search the ads in *Astronomy* magazine. Find the telescopes you’re interested in. Then visit the websites listed in the ads. Be sure to ask your parents and teachers what they think. And if there’s an astronomy club near where you live, go to one of its meetings and find out when it will be doing a sky viewing for the public. That will be a great time to go around and ask questions of people who already own telescopes. Good luck!

TYPES OF MOUNTS

We put telescopes on mounts to make them easy to use. You sure wouldn’t see much if you had to hold a big telescope up to your eye using just your hands! Mounts have controls on them to let you follow objects moving through the sky. They move because Earth is turning, and that makes everything in the sky look like it’s moving in the other direction.

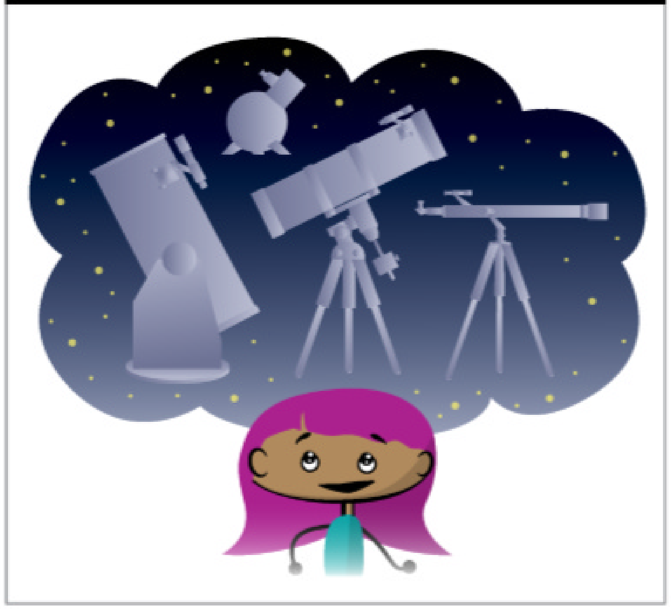
Most beginner telescopes attach to a simple mount that lets you move it up and down and left and right. But some are set up to move in a way that matches the movement of the sky.

The first type is called an alt-azimuth mount. You’ll find that it’s pretty easy to use. But to follow objects with it, you have to move the mount in two directions.

The second type, called an equatorial mount, makes it easier to track sky objects, but it’s a lot harder to set up.

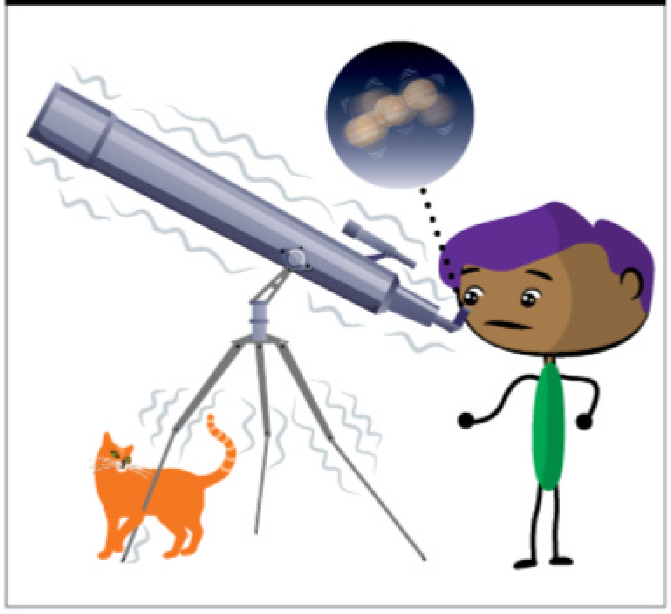
Here’s what’s important: It doesn’t matter which kind of mount you get, as long as it’s sturdy.

DO YOUR HOMEWORK



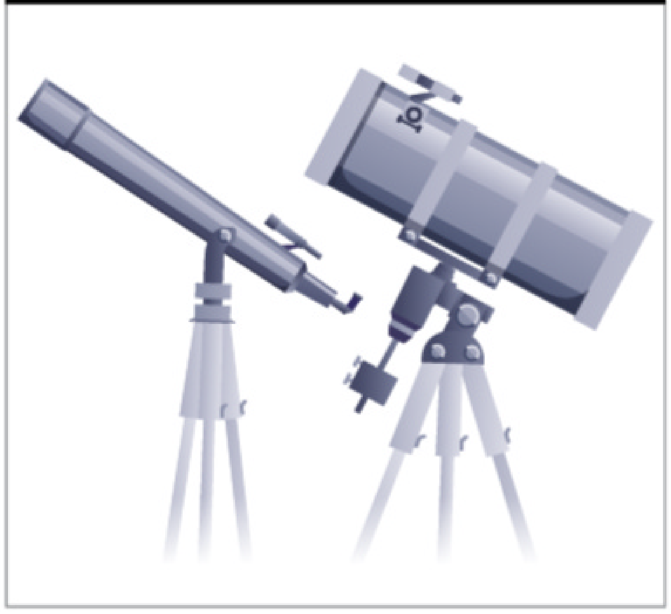
Read as much as you can about the different kinds of telescopes. That will help you make the right choice.

A GOOD BASE



The telescope is just half of what you need. You’ll also need to pick a sturdy tripod that won’t shake easily.

THE RIGHT ONE FOR YOU



Learning about telescopes will help you pick one you’ll be happy with for years!

SOLAR FILTER: CLAUDIODIVIZIA/DREAMSTIME

ASTRONOMY: ROEN KELLY

Learn about comets

by Michael E. Bakich

What is a comet?

Comets are dark, solid bodies a few miles across. Scientists describe them as “dirty snowballs” because they are a mix of dust and frozen gases.

Astronomers call a comet’s solid part its nucleus. Some of the nucleus’s ice turns into gas when the comet gets close to the Sun. As the ice changes, the dust inside it also is released. This creates a ball of gas and dust that surrounds the nucleus, called the coma. It can extend 620,000 miles (1 million kilometers). Sunlight sweeps this material away from the nucleus, and that’s what makes the comet’s tails.

Comets usually have two tails. The gas tail glows blue and points directly away from the Sun. Dust given off by the comet creates a wider, brighter, curving yellow tail. A comet’s tails can be as long as the distance between Earth and the Sun!

How do comets get their names?

A comet can be named for up to three of its discoverers. And some of those discoverers might not be people. Observatories and satellites also can get credit for discovering comets.

Astronomers always give comets an official catalog number. It begins with one letter, usually a C for “comet” or a P for “periodic” (meaning that it will return), followed by the discovery year and a letter that tells in which half-month the discovery occurred. A is January 1 though 15, B is January 16 through 31, and so on. I and Z are never used.

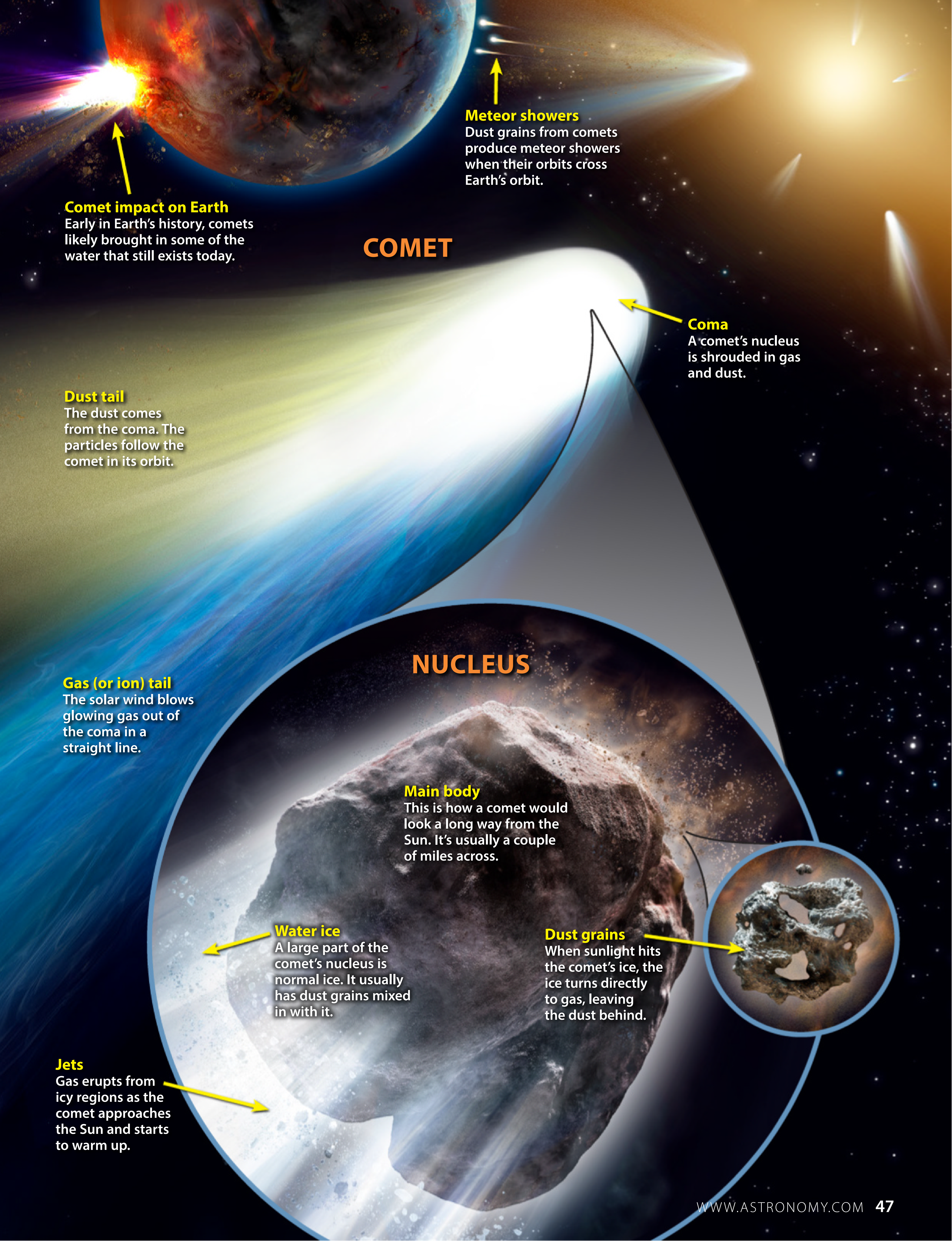
But what if two or more comets are found in the same half-month? Astronomers add a number showing the order of the discoveries. Here’s an example: Comet Lovejoy was the fourth comet discovered in the first half of March 2017, so its official number is C/2017 E4.

Why are comet orbits so weird?

Astronomers think comets come from two areas. The inner one is shaped like a thick disk. It begins near Neptune and goes out about 50 times Earth’s distance from the Sun. This is the Kuiper Belt, and it contains about 70,000 objects larger than 62 miles (100 km) across.

The Kuiper Belt lies in a much larger comet cloud called the Oort Cloud. It starts where the Kuiper Belt ends and goes out to more than 60,000 times the distance between Earth and the Sun. That’s about one-quarter of the way to the nearest star! Astronomers think the Oort Cloud contains 2 trillion comets.

Stars don’t have to get close to Earth to have an effect on us. If a star passes close enough to the Oort Cloud, the star’s gravity can nudge some of the comets there and start them on a trip toward the Sun. The trip might take a million years, but comets are patient. Because the Oort Cloud surrounds us, these comets can come from any direction.



Comet impact on Earth
Early in Earth's history, comets likely brought in some of the water that still exists today.

Meteor showers
Dust grains from comets produce meteor showers when their orbits cross Earth's orbit.

COMET

Coma
A comet's nucleus is shrouded in gas and dust.

Dust tail
The dust comes from the coma. The particles follow the comet in its orbit.

Gas (or ion) tail
The solar wind blows glowing gas out of the coma in a straight line.

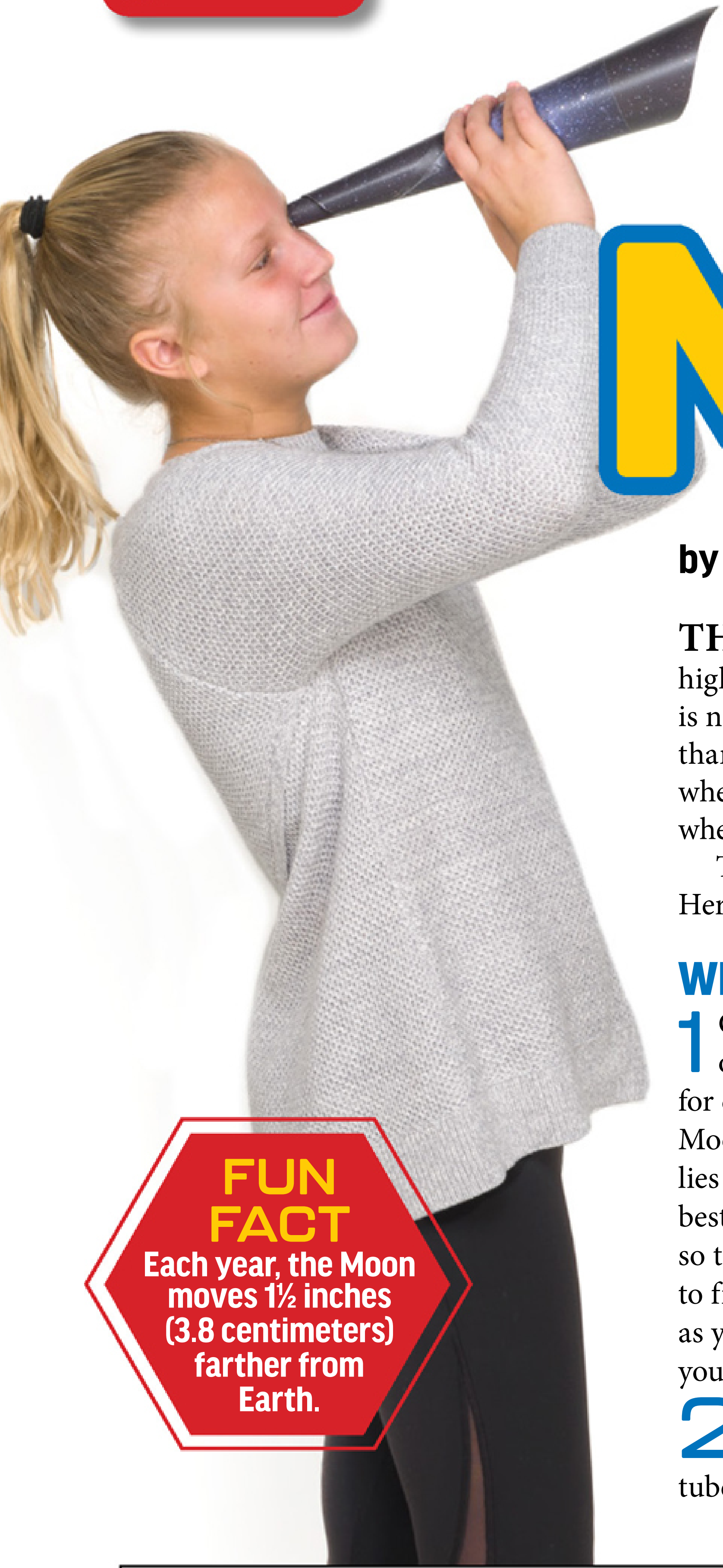
NUCLEUS

Main body
This is how a comet would look a long way from the Sun. It's usually a couple of miles across.

Water ice
A large part of the comet's nucleus is normal ice. It usually has dust grains mixed in with it.

Dust grains
When sunlight hits the comet's ice, the ice turns directly to gas, leaving the dust behind.

Jets
Gas erupts from icy regions as the comet approaches the Sun and starts to warm up.



Sizing up the MOON

by Michael E. Bakich

THE FULL MOON LOOKS BIGGER while it is rising than when it's high in the sky. But it's not bigger — it's actually a little bit smaller. When the Moon is near the ground, it's about 4,000 miles (6,440 kilometers) farther away from you than when it's overhead. So, it's smaller near the ground (by about 1½ percent) than when you see it high in the sky. Somehow our mind tricks us into thinking it's bigger when it's rising. Astronomers call this effect the Moon Illusion.

There's an easy way to prove the Moon isn't bigger when it's near the ground. Here's how.

What to do

1 Go outside around sunset on the date of a Full Moon. Check the table below for dates of the Full Moon. Find the Moon as it rises. **Hint:** The Full Moon lies across the sky from the Sun, so the best way to look for the Moon is to stand so the Sun (or sunset) is behind you. Try to find the Moon as close to the ground as you can. Notice how big it looks when you just use your eyes.

2 Carefully roll a sheet of paper into a tube, so that the Moon fills the tube when you look through it.

3 Tape the tube at that size.

4 Look at the Moon again through the tube to be sure the tube's size didn't change while you were taping it. If it did, repeat steps 2 and 3.

5 Go inside for 3 hours. During this time, the Moon will rise higher in the sky.

6 Go back outside, and find the Moon. Does it look bigger, smaller, or the same size when you just look at it with your eyes?

7 Now look at it through the tube. Has the Moon's size changed?

FUN FACT

Each year, the Moon moves 1½ inches (3.8 centimeters) farther from Earth.

DATES OF UPCOMING FULL MOONS (IN THE U.S.)

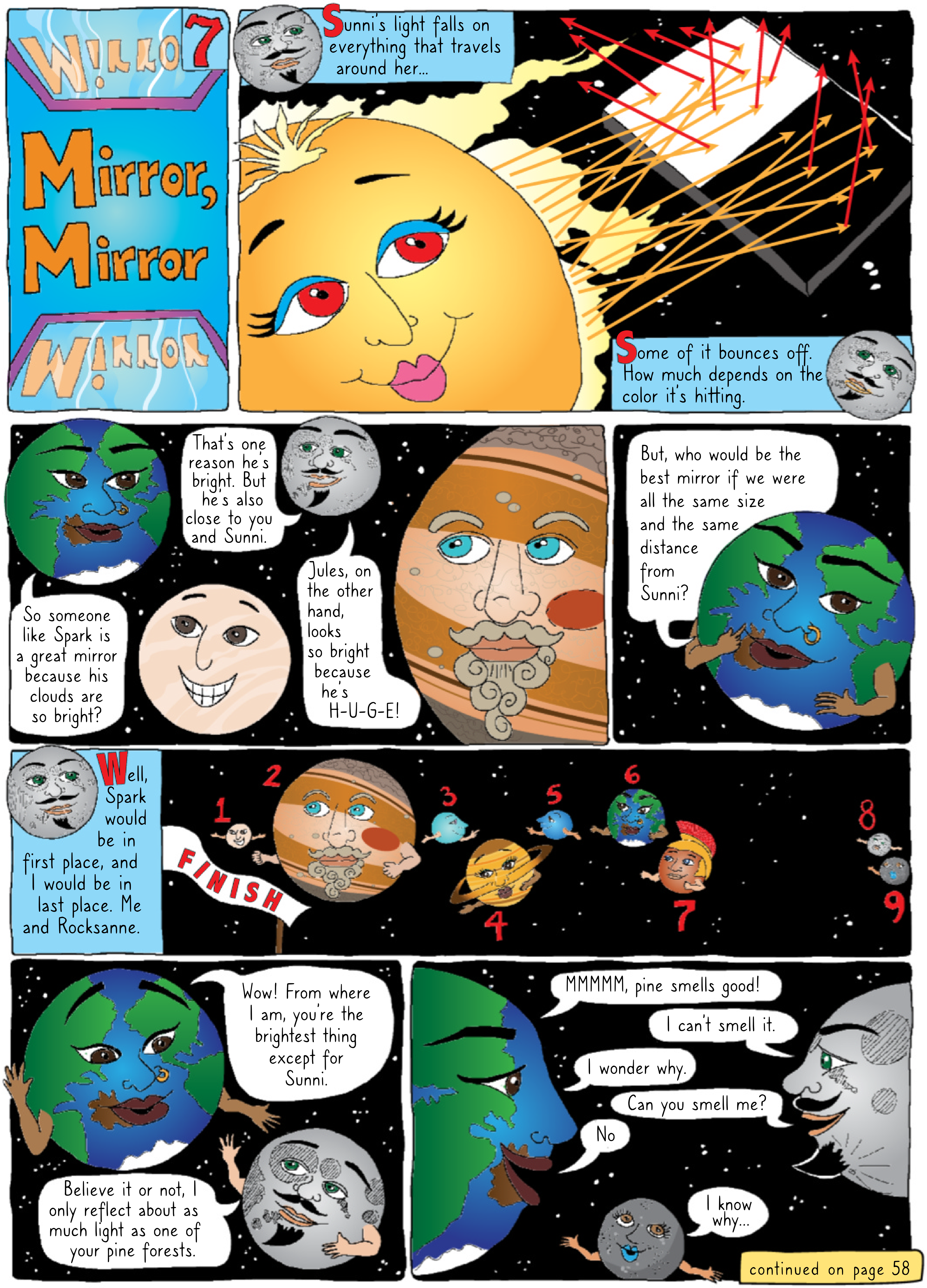
2020	2021	2022	2023
Jan 10	Jan 28	Jan 17	Jan 6
Feb 9	Feb 27	Feb 16	Feb 5
Mar 9	Mar 28	Mar 18	Mar 7
Apr 7	Apr 26	Apr 16	Apr 6
May 7	May 26	May 16	May 5
Jun 5	Jun 24	Jun 14	Jun 3
Jul 5	Jul 23	Jul 13	Jul 3
Aug 3	Aug 22	Aug 11	Aug 1 and 30
Sep 2	Sep 20	Sep 10	Sep 29
Oct 1 and 31	Oct 20	Oct 9	Oct 28
Nov 30	Nov 19	Nov 8	Nov 27
Dec 29	Dec 18	Dec 7	Dec 27

WHAT YOU'LL NEED!

☐ A sheet of paper
(Plain white paper is fine, but it might be fun to decorate one side of it with space-related stuff.)

☐ One piece of tape

GIRL: ASTRONOMY: WILLIAM ZUBACK. MOON: ONYXPRJ/DREAMSTIME. TAPE: HOLLEY BAKICH


7
Mirror, Mirror
Sunni's light falls on everything that travels around her...
Some of it bounces off. How much depends on the color it's hitting.
That's one reason he's bright. But he's also close to you and Sunni.
So someone like Spark is a great mirror because his clouds are so bright?
Jules, on the other hand, looks so bright because he's H-U-G-E!
But, who would be the best mirror if we were all the same size and the same distance from Sunni?
Well, Spark would be in first place, and I would be in last place. Me and Rocksanne.
FINISH
1
2
3
4
5
6
7
8
9
Wow! From where I am, you're the brightest thing except for Sunni.
Believe it or not, I only reflect about as much light as one of your pine forests.
MMMMM, pine smells good!
I can't smell it.
I wonder why.
Can you smell me?
No
I know why...

continued on page 58

Let's make a COMET

by Mike Reynolds

PEOPLE ENJOY LOOKING AT COMETS, especially bright ones. They are small, usually just a mile or so across, and their shapes are irregular. Comets are made of dust and frozen gases. Many of them travel along stretched-out orbits that sometimes bring them close to the Sun, and then take them far into space, way beyond Pluto's orbit.

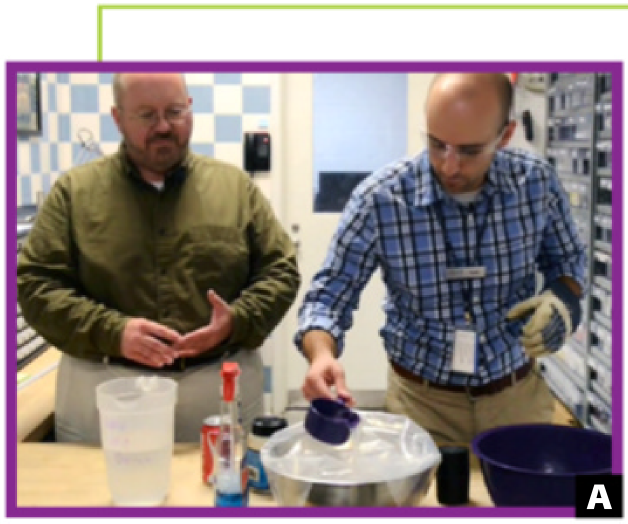
IMPORTANT SAFETY TIPS

You must have an adult help you make your comet. Not only can comet-making be messy, but dry ice is so cold, it will cause frostbite. (Dry ice has a temperature of –109 degrees Fahrenheit or –78.5 degrees Celsius.) Also, a big sniff of ammonia could make you pass out, and breathing too much ammonia will hurt your lungs. But if you have the help of a teacher or a parent, making a comet can be safe, fun, and a real learning experience!

If you look at a comet or a photo of a comet, you'll see a couple of things. The round part is the coma, the gas that boils off the comet and then surrounds it. The coma can be tens of thousands of miles across. As a comet gets close to the Sun, a tail forms. Some comets have long tails, up to tens of millions of miles long, and some have two tails, one made of dust and the other of gas. When a comet has two tails, it's easy to tell which is which. The dust tail is always curved, and the gas tail is straight.

NASA and other space agencies have sent spacecraft to collect data about comets. The first spacecraft to do so was Giotto, which came within 370 miles (595 kilometers) of Halley's Comet in 1986. Since then, there have been several other space missions that have visited comets.

The main part of comets can be made of lots of stuff: rocks, dust, water ice, dry ice, other frozen gases, and organic material, which is stuff made of carbon mixed with oxygen, hydrogen, and nitrogen. Oil is an organic material, and so is alcohol. Because of this mix, one astronomer called comets "dirty snowballs." Luckily, we can find the stuff that's inside comets around the house or at a store. So let's make a comet!



A

B

Making a comet is fun, but you have to be really careful when you handle dry ice.

ADLER PLANETARIUM

Here's what a comet would look like if you could get close to one. In 1986, the European Space Agency's Giotto spacecraft photographed Halley's Comet from just 370 miles (595 kilometers) away. HALLEY MULTICOLOR CAMERA TEAM/GIOTTO PROJECT/ESA

WHAT! YOU'LL NEED!

☐ 2 teaspoons rubbing alcohol (You can use isopropyl alcohol.)

☐ 1 teaspoon ammonia (You can use cleaning ammonia.)

☐ ½ cup charcoal (Use a briquette that doesn't contain wood pieces.)

☐ 3 pounds dry ice (Many grocery stores sell it.)

☐ 2 teaspoons pancake syrup (This represents the organic material that's in comets.)

☐ ½ cup sand

☐ 2 cups ice cubes

☐ 1 tablespoon cornstarch (This is to help the stuff in our comet stick together.)

☐ Aprons (for everyone helping to make the comet)

☐ Large mixing bowl

☐ 1-gallon baggie or a small, thick trash bag

☐ Heavy-duty gloves (for everyone helping to make the comet)

☐ Goggles (for everyone helping to make the comet)

☐ Rubber mallet

☐ Newspaper

☐ Mixing spoon or spatula

Putting it together

1 Collect all materials and supplies where you will make your comet. Put on your apron, and put on your gloves if you are handling the dry ice.

2 Place the charcoal briquette in a heavy-duty baggie or wrapped with paper. Then use the rubber mallet to crush it as much as possible into fine, sandy pieces.

3 Now use the mallet to break the ice cubes into small pieces, but not as small as the charcoal.

4 Open the 1-gallon baggie and put it over the mixing bowl (picture A, below). This will help it to stay in place. Add the ice, charcoal, sand, ammonia, rubbing alcohol, cornstarch, and syrup (picture B). You might need someone to hold up the baggie as you add your comet materials. Using the spoon, mix everything completely.

5 Wearing your gloves and goggles for protection, get the dry ice. If the dry ice isn't in a bag or wrapped, wrap some newspaper around it. Use the rubber mallet to break the dry ice into small pieces.

6 Carefully add the dry ice to the mixture in the baggie. You might see some steam released as you add the dry ice. With your gloves still on, squeeze the baggie gently to form your comet into a ball (picture C). Try to keep it in the baggie.

7 **CAREFULLY** remove your comet from the baggie (picture D).

Now answer these questions

1. What color is your comet?
2. Is the color the same all over the comet?
3. Does your comet continue to release gas?
4. What gas do you think is being given off?
5. Compare your comet with real comet images. How is it the same or different?
6. Wearing your gloves and goggles, pick up and move your comet. What happens to the gas it's giving off? Note: You can use a fan or hair dryer aimed at your comet to answer this question.
7. Over a period of time, what happens to your comet?

C

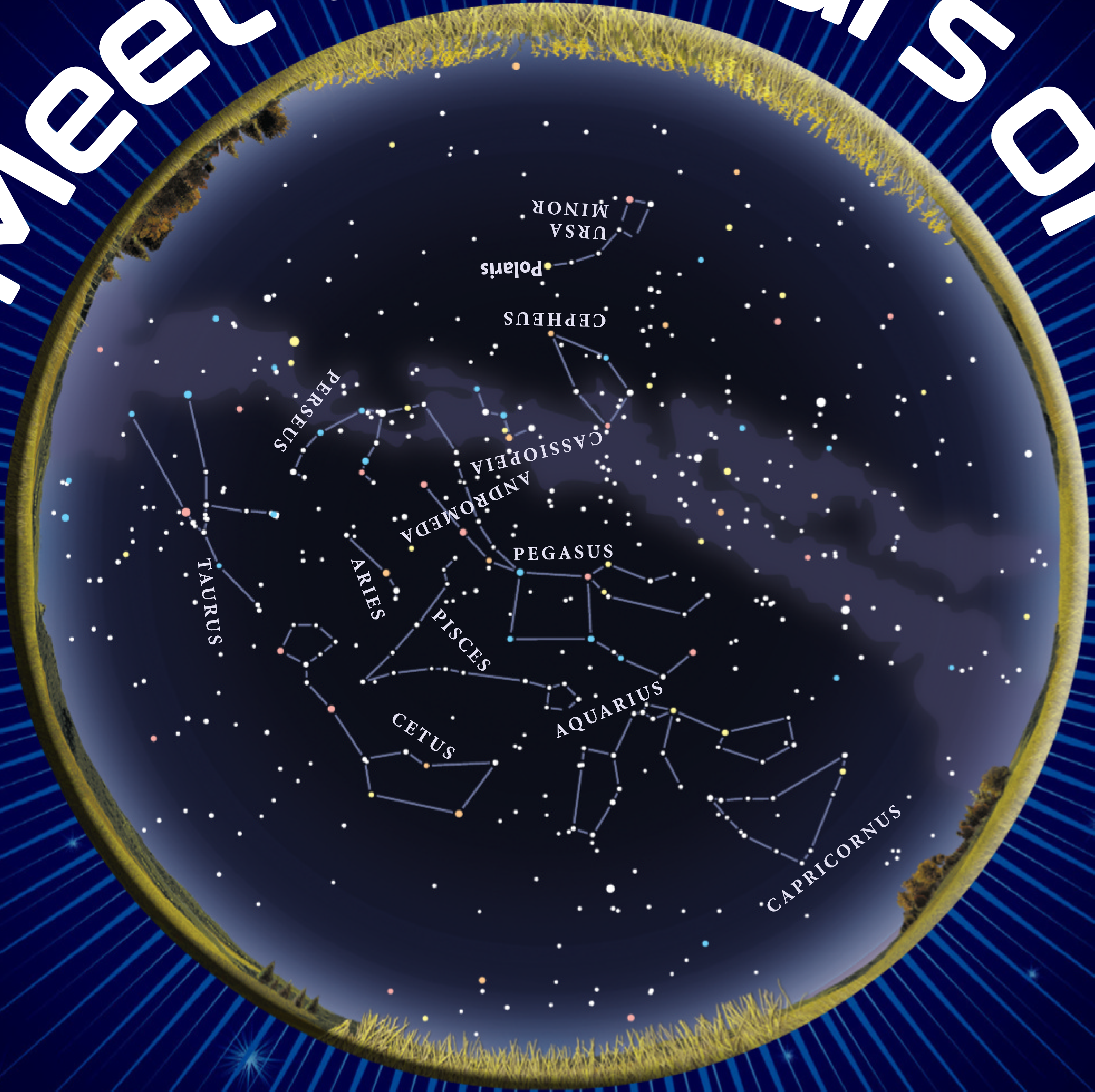
D

IMPORTANT

When you're done examining your comet, dispose of it properly. Bag it up and put your comet into your outside garbage. Do NOT put your comet remains in the sink or flush it down the toilet.

SAFETY GOGGLES: TINA ZOVTEVA/DREAMSTIME

Meet the stars of FALL


URSA MINOR
Polaris
CEPHEUS
PERSEUS
CASSIOPEIA
ANDROMEDA
PEGASUS
TAURUS
ARIES
PISCES
CETUS
AQUARIUS
CAPRICORNUS

by Raymond Shubinski

The Big Dipper swings low this season, and depending on where you are, it might even set. Pegasus the Winged Horse rides high in the sky along with Cassiopeia the Queen, Cepheus the King, and the other constellations that tell the story of Perseus and Andromeda. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

WHEN FALL BEGINS, you can feel and see changes all around you. The days get shorter, and nights are cooler. In the sky, the summer constellations are setting in the west, and new star groups are rising in the east.

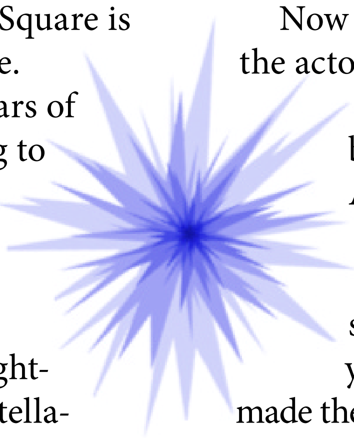
Any time in the fall, go outside an hour after sunset. In the summer, Ursa Major the Great Bear was in the north. But even when it was high in the sky, it was hard to make a picture out of stars that looked like a bear. In the fall, most of the bear is so low that it's hidden by the ground.

But if there are no trees or houses in the way, you still can find the seven stars of the Big Dipper. Its two Pointer Stars will help you find Polaris, the North Star. Just draw a line between the two stars at the end of the bowl and follow them to Polaris.

Native Americans tell of a hunting party chasing the Great Bear. As they run after him, they shoot an arrow and wound him. The story says that leaves change color in the fall because some of the bear's blood drips down to Earth and turns them red and orange.

The stars of fall tell another wonderful story. The characters in this Greek myth are Cassiopeia the Queen, Cepheus the King, Andromeda the Princess, Perseus the Hero, Pegasus the Winged Horse, and Cetus the Sea Monster.

Start by finding Pegasus. The easiest way is to first find its main part, the Great Square. Pegasus flies high in the fall sky on mighty wings. In pictures, the horse is flying out of a cloud, so only its top half makes this constellation. It's hard to find the horse, but luckily the Great Square is much easier to see.



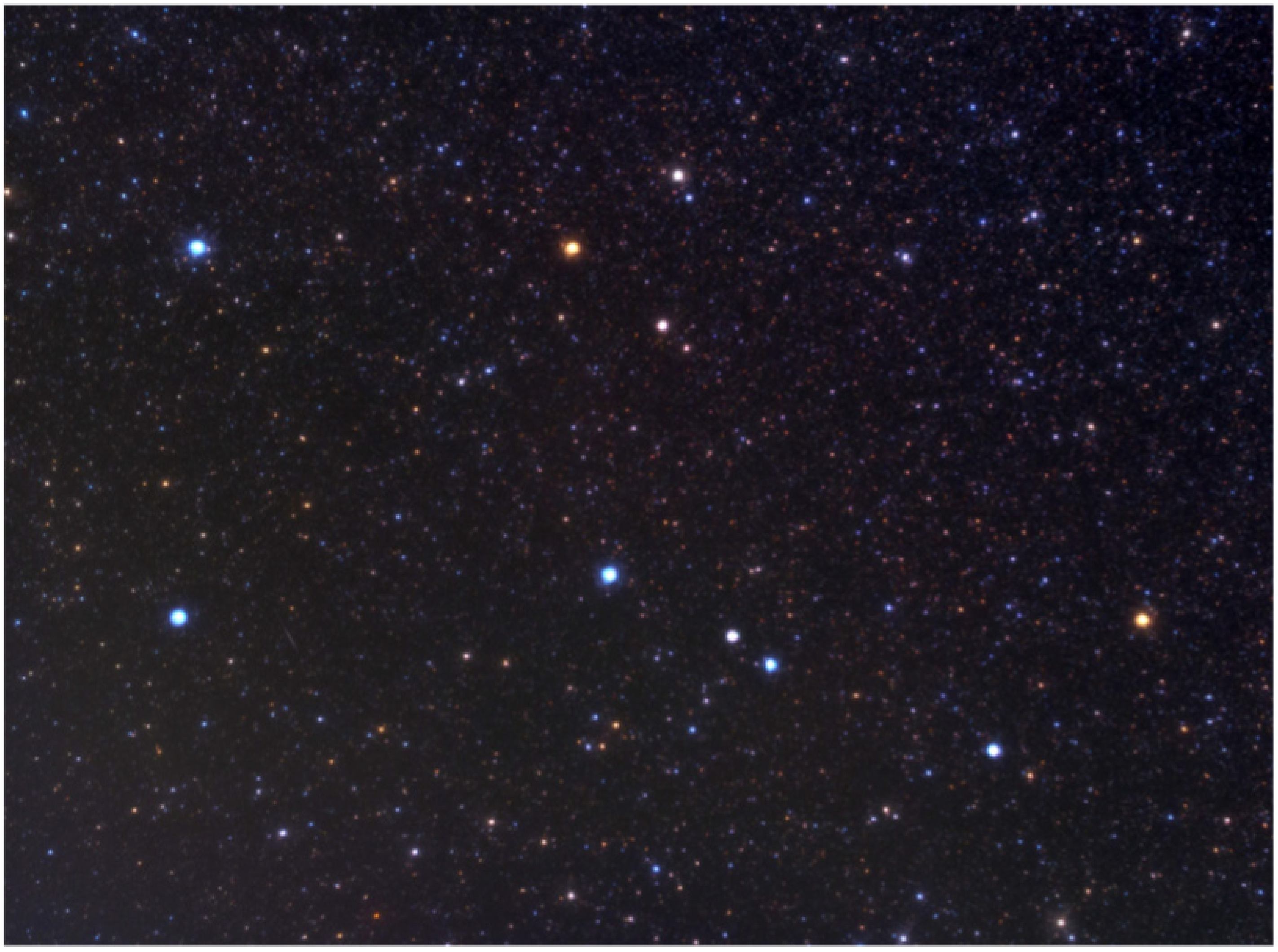
Not all four stars of the Square belong to Pegasus. The one highest in the sky, named Alpheratz, is Andromeda's brightest star. Her constellation looks like a long, thin letter V made of stars stretching out from the Square. Andromeda was the daughter of Cassiopeia and Cepheus.

Cassiopeia is in the northeast. To find that direction, first find Polaris. It's always in the north. Northeast is just a bit to the right of Polaris, and that's where you'll find Cassiopeia. The Queen is sitting on her throne, which is hard to imagine. It's a lot easier to see a sideways letter W made of five fairly bright stars. Cassiopeia's husband, Cepheus, is above Polaris at this time of year. Some people think the constellation Cepheus looks like a house with a very steep roof.

Now that you've found all the actors, let's get back to our story. The queen bragged that Andromeda was more beautiful than the daughters of the sea god, Poseidon. As you might guess, this made the sea god very angry!

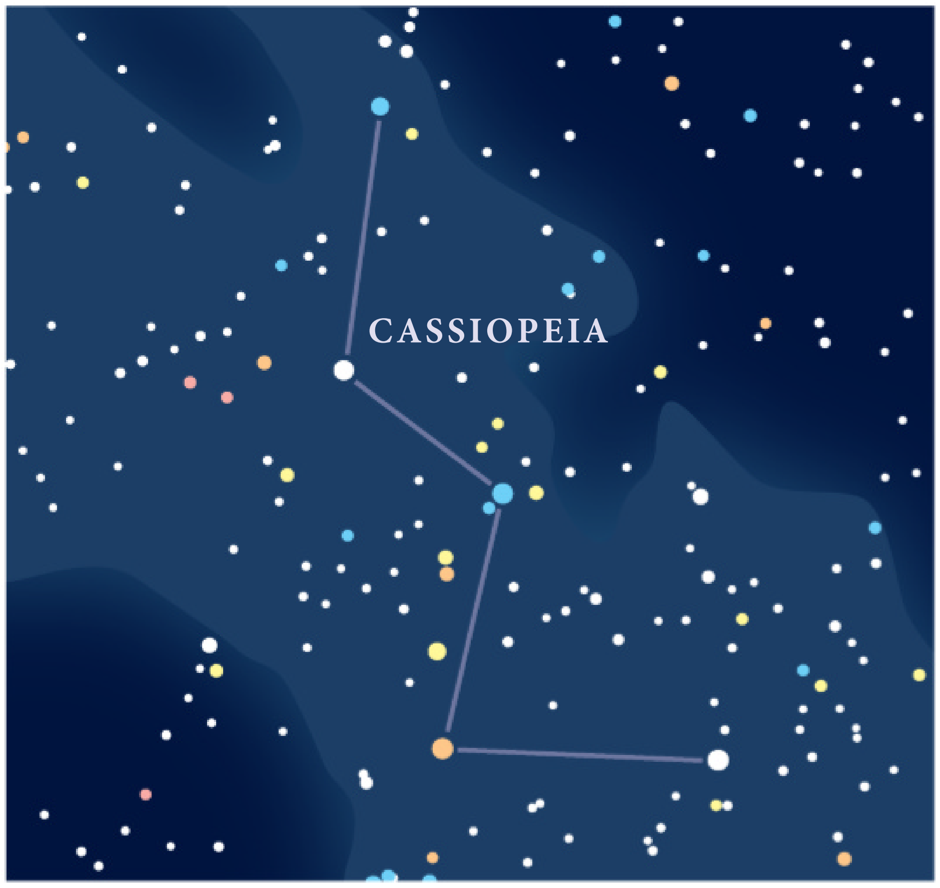
Because of what Cassiopeia said, Andromeda was chained to a rock by Poseidon to be eaten by Cetus. To find the constellation Cetus, look low in the sky toward the southeast. It's a large figure with five sides.

Now in the story, Perseus happened to be riding

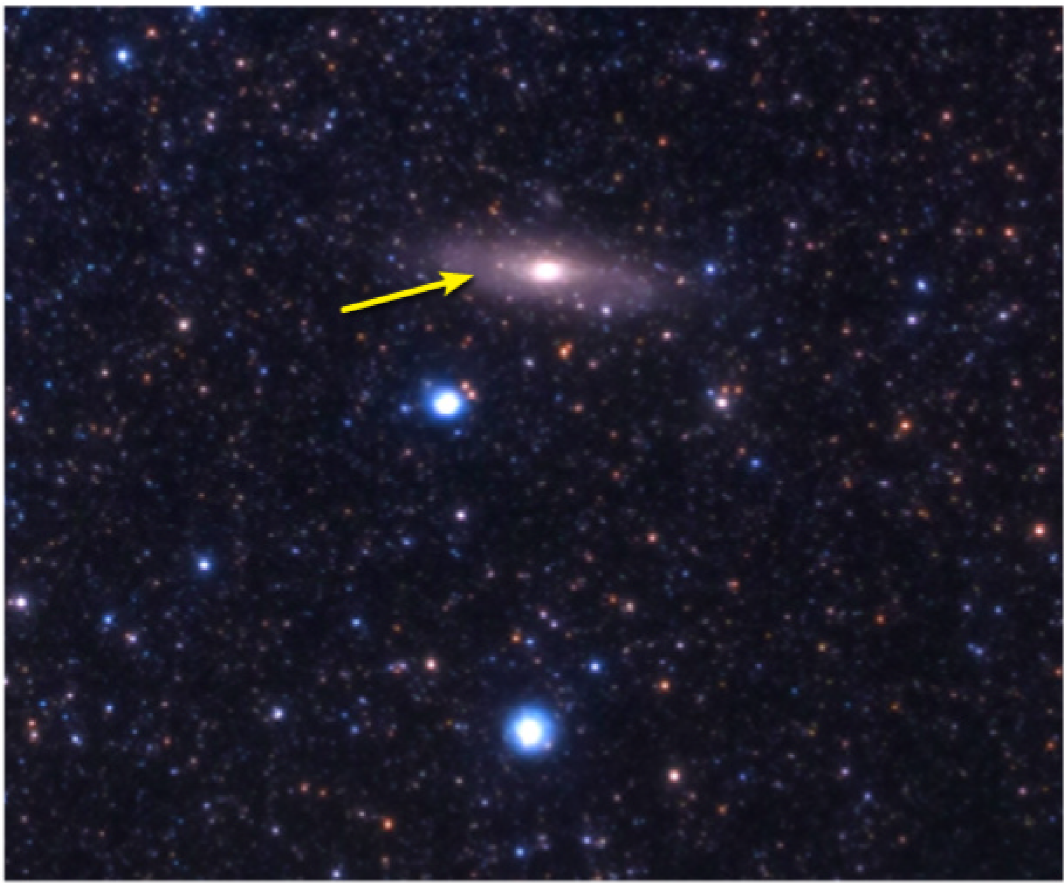


The main part of Pegasus is called the Great Square, even though the blue star at the Square's upper left belongs to Andromeda. TONY HALLAS

OPPOSITE PAGE BACKGROUND: NATALIA KUCHUMOVA/DREAMSTIME. STARBURST: ILLIA HRYHORIEV/DREAMSTIME. CHILDREN: ANNA VITEEVA/DREAMSTIME



The main part of Cassiopeia the Queen looks like the letter W. But when it's high in the sky, it might look like the letter M to you. Its stars are bright, so Cassiopeia is easy to see in the fall sky. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY



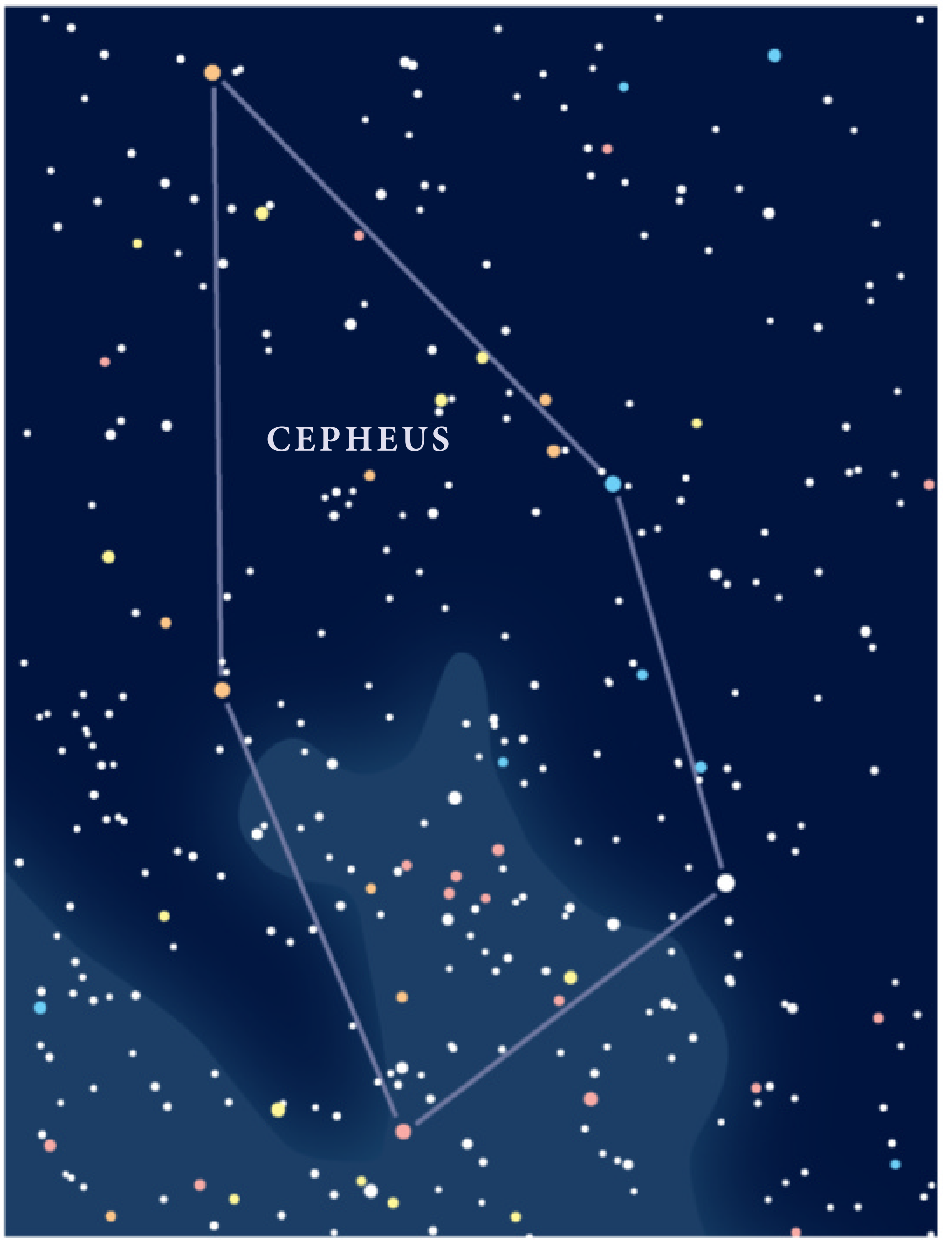
The Andromeda Galaxy (arrow) is a huge group of stars that's a lot like our Milky Way Galaxy. It's named for the constellation it's in, Andromeda the Princess. TONY HALLAS

Pegasus and flying by just as Andromeda was about to be eaten. He flew between Cetus and Andromeda and took out the head of the monster Medusa, whom he had recently slain.

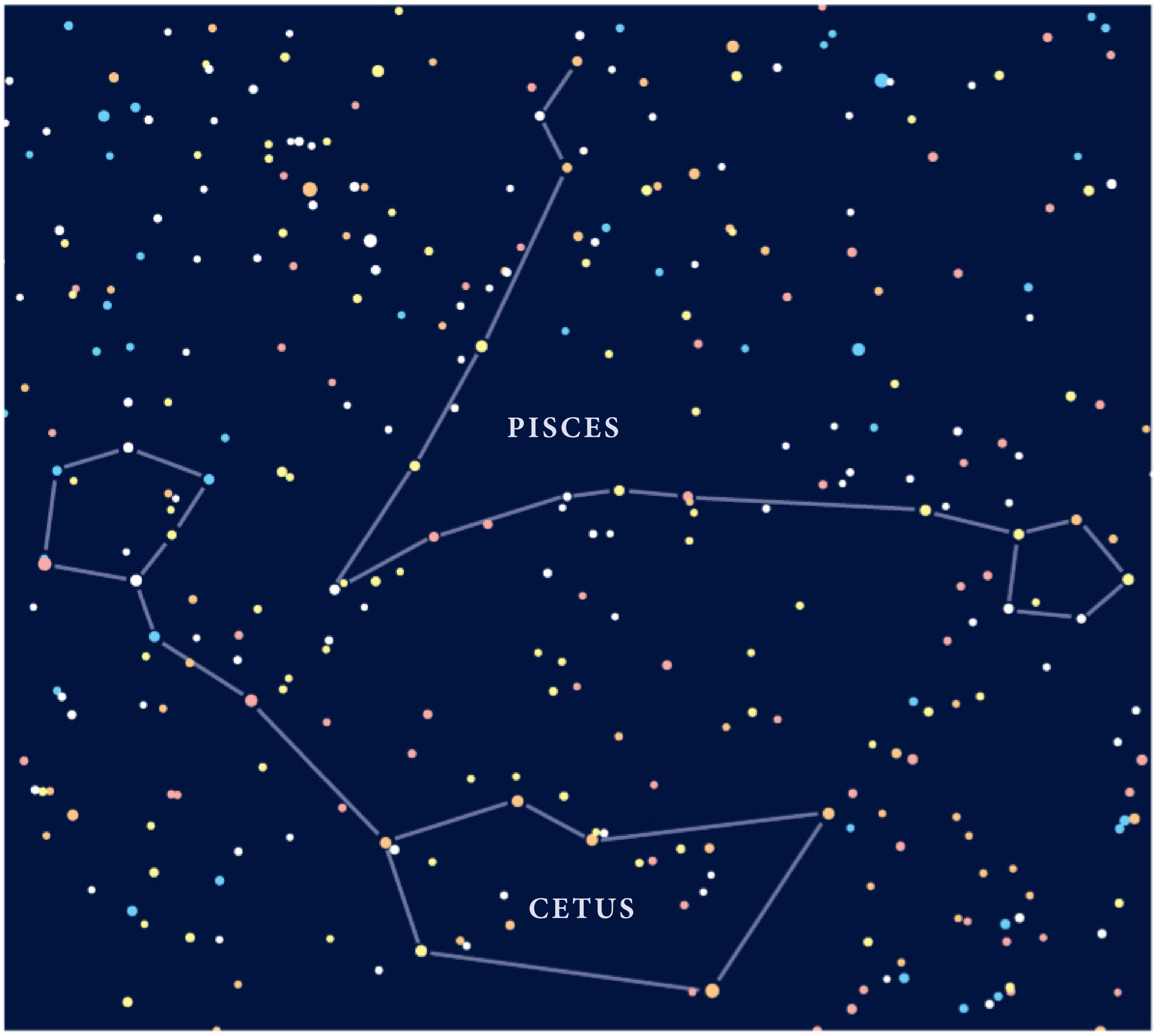
Medusa wielded a special power: Whomever looked at her would immediately turn to stone. When Cetus saw Medusa's head, it turned to stone and crumbled into the sea. Perseus then freed Andromeda, and they were married.

You'll find the constellation Perseus at the feet of Andromeda. It's in the east, about halfway up in the sky. And if you want to see Medusa's head, look for Perseus' second-brightest star, Algol. It's also known as the demon star. Anyone recognize the star as part of Ra's al-Ghul's name from the *Gotham* or *Arrow* television shows or *Batman* comics?

But Algol isn't just one star. It's two. One is blue, and the other is red. As we watch them, the two stars orbit each other. But they also pass in



Cepheus the King has five main stars. Its figure looks like a house with a steep roof. Look high in the north this time of year to find it. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY



Two of the faintest constellations in the fall sky are Pisces the Fish and Cetus the Sea Monster (or Whale). You'll need a good star chart to pick them out. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

front of one another, and that changes Algol's brightness. When the dimmer red star covers the brighter blue one, Algol doesn't look so bright. A few hours later, however, when the red star isn't covering the blue one anymore, Algol comes back to its normal brightness. The time it takes for Algol complete this cycle of brightness is 2 days, 20 hours, 38 minutes, and 24 seconds. Astronomy is really precise!

Now before you leave the fall sky, let's find two more constellations. The first one is big, but its stars are dim, so you might not see it on your first try. Look just below Pegasus, and you'll see a small circle of stars. This is one of the two fish in the constellation Pisces. From that circle, there's a line of stars that goes down to Cetus. Another line of stars comes back up from Cetus. The two lines form a large letter V. A small squashed circle of stars — the second fish — is at the end of the second line. Pictures of Pisces show the two fish tied together.

Just below Pisces is a much smaller constellation called Aries the Ram, and it's a lot easier to see than Pisces. Its brightest star has an Arabic name, Hamal, and marks the head of the Ram. To the right and close to Hamal are two other fairly bright stars. Those three form the head of the Ram. Hamal is an old giant star. If your sky is dark, you might see a bit of red color in it.

The faint glow of the Milky Way, running from the northeast to the southwest, cuts the sky in half. To the east, the new constellations of fall are coming into view. On the western side, we can still see a few constellations of summer. As fall goes on, its stars will rise higher in the sky. Then, just like the stars of summer, they will make their way west until the stars of winter push them aside.

FUN FACT

If you have binoculars, you can see another galaxy a lot like the Milky Way. It's in the constellation Andromeda. Aim your binoculars about halfway between the Great Square of Pegasus and Cassiopeia. The fuzzy patch of light you'll see is the Andromeda Galaxy. And here's something cool: Although it's one of the closest galaxies to us, this galaxy's light has traveled more than 2 million years to reach your eyes.

MAKE YOUR OWN CRA

If you look at the Moon through a telescope, you'll see lots of holes. Most are craters caused by small (and even big) rocks hitting the Moon. Scientists call them impact craters. They're different from the other type of craters we see on the Moon and on Earth, which are caused by volcanoes. When something hits the Moon, soil and rocks get blasted away from the area, a crater forms, and sometimes rays also form. Rays are lighter material that shoots out in streaks; sometimes they look like the spokes of a bicycle wheel.

You'd think our planet would have a lot more craters than the Moon because it's so much bigger. But we don't see many craters on Earth for two reasons. The first is that most of the stuff that hits our planet burns up in the atmosphere or lands in the ocean. (About 71 percent of Earth's surface is covered with water.) The second reason is that weather makes older craters erode (or wear away).

Let's explore how impact craters form, then we'll make our own. We find small and large rocks (scientists call them impactors) that make craters on all solid bodies in our solar system. In fact, did you know that impact craters are the most common feature on the planets, moons, and asteroids?

Impactors are traveling at high speeds. When one hits, it makes a shock wave that breaks rock and digs out a hole usually many times larger than the impactor. Most of the time, the impactor breaks apart. The impact can even create a temperature high enough to melt rock.

OK, are you ready to make some craters? Your impactors won't be going as fast as the ones in space, but that's OK because your planet "surface" is a lot softer. And you certainly will see the effect an impactor can have.

What to do

1 **Optional:** Spread newspaper or large garbage bags under your pan. This will help in cleanup. Some impact material can splash a long distance.

2 Spread a 1-inch-thick layer of flour in the bottom of the pan. Flour represents the light-colored rock that's underneath the surface.

WHAT! YOU'LL NEED

☐ Metal baking pan
(Do not use glass!)

☐ Flour

☐ Rainbow cake sprinkles

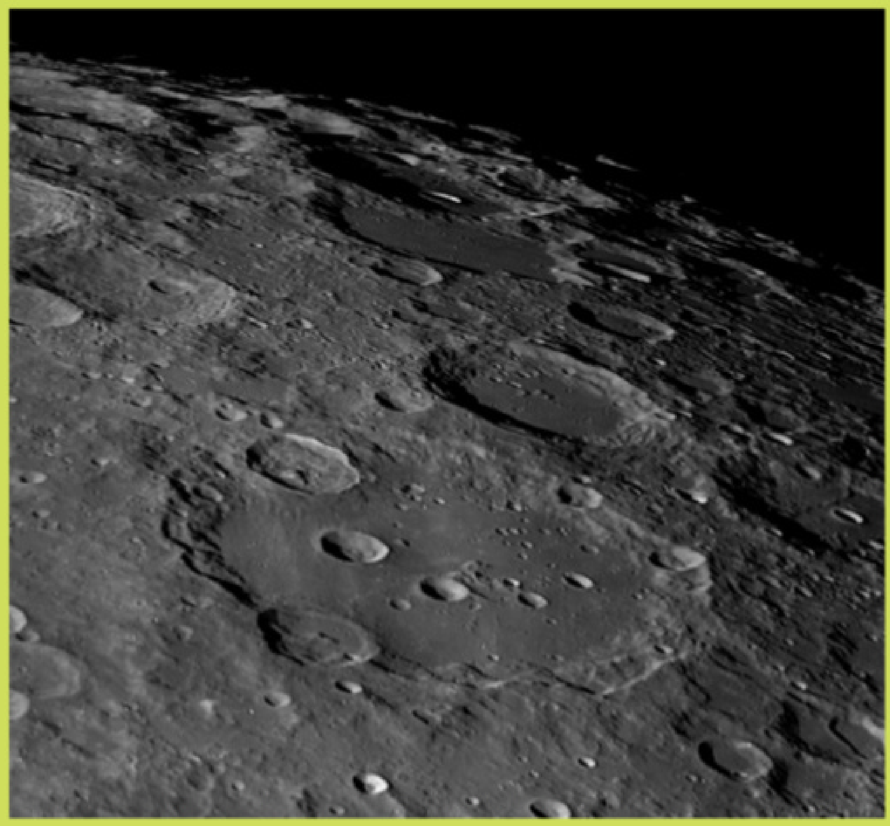
☐ Cocoa or powdered chocolate

☐ Sifter
(A spoon will work if you don't have a sifter.)

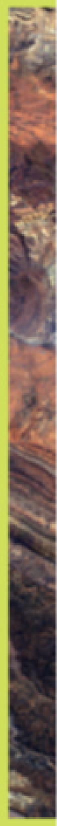
☐ Impactors — small rocks, marbles, or fishing weights of different sizes

REAL CRATERS ON THE MOON AND EARTH

RIGHT: Clavius Crater on the Moon is a great target for small telescopes because you can see lots of smaller craters inside it. Those formed later than the main crater when meteorites hit the part of the Moon where Clavius is. DAMIAN PEACH

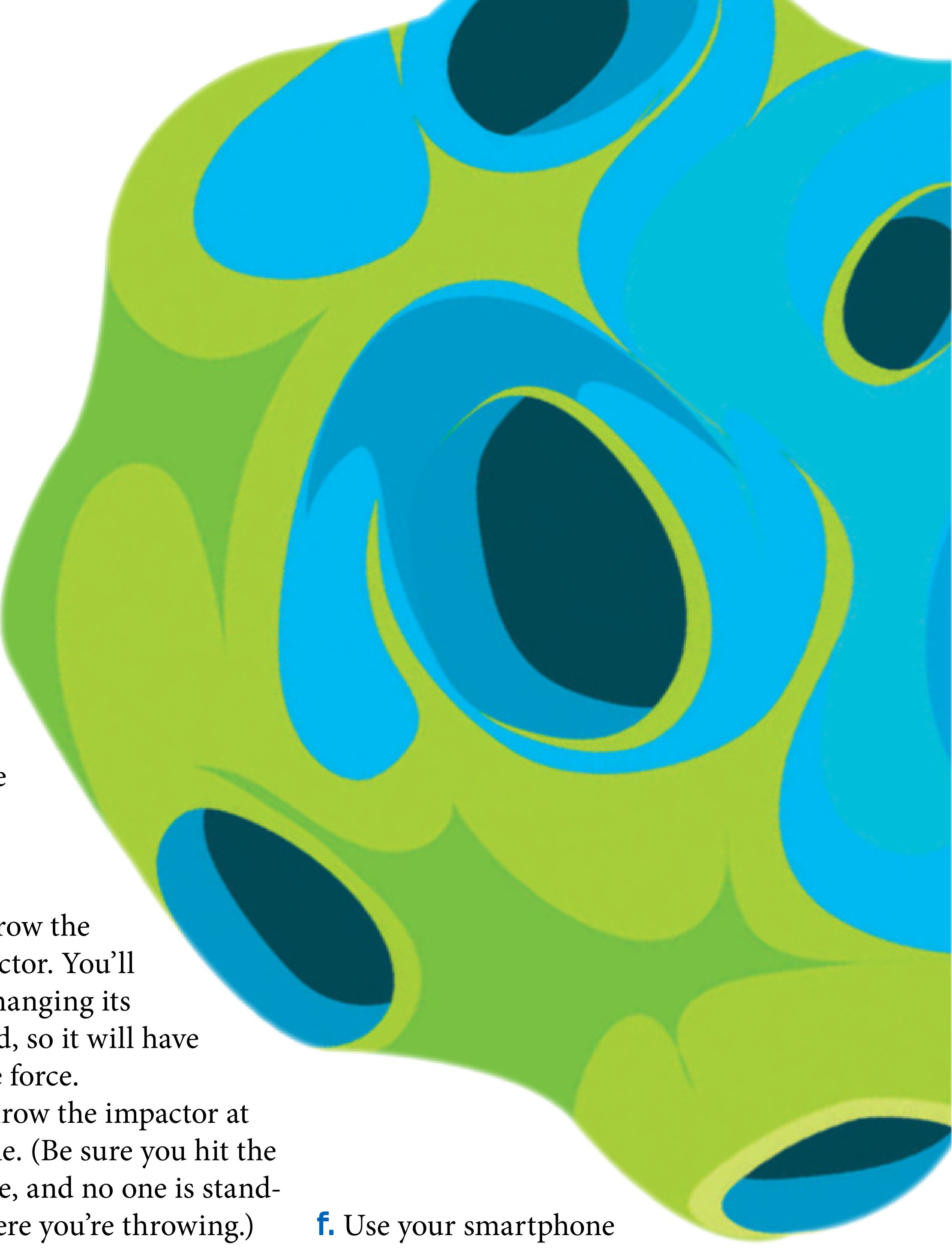


CENTER: Earth gets hit, too! A meteorite hit the Gosses Bluff Crater in Australia 142 million years ago. The crater measures 15 miles (24 kilometers) across and 3 miles (5 km) deep. The circular ring of hills at the center is 3 miles across. It formed when the ground bounced back after the impact. NASA/USGS



by Mike Reynolds

ATERS



3 Add a thin layer of cake sprinkles; it doesn't need to completely cover the flour. They represent rocks.

4 Add a layer of cocoa or powdered chocolate. (Nestlé's Quik works great!) Chocolate represents the darker stuff that's on the surface. A sifter will give you a nice, even layer, but you can spoon it on if you don't have a sifter.

5 Make a crater by dropping one of your impactors into the pan from about the height of your head. Aim carefully so you don't hit yourself or someone else. What do you see? Is there a crater? What about crater rays?

6 You can do this experiment as many times as you like. Just re-create your impact site (the pan) after each test. Here are some things to try:

a. Change the height from which you drop your impactor.

b. Change the impactor. A fishing weight is dense and can make an incredible impact.

c. Throw the impactor. You'll be changing its speed, so it will have more force.

d. Throw the impactor at an angle. (Be sure you hit the impact site, and no one is standing behind where you're throwing.)

e. Use a ruler to measure the lengths of the rays that formed. Compare them to others you made by dropping the impactor from different heights.

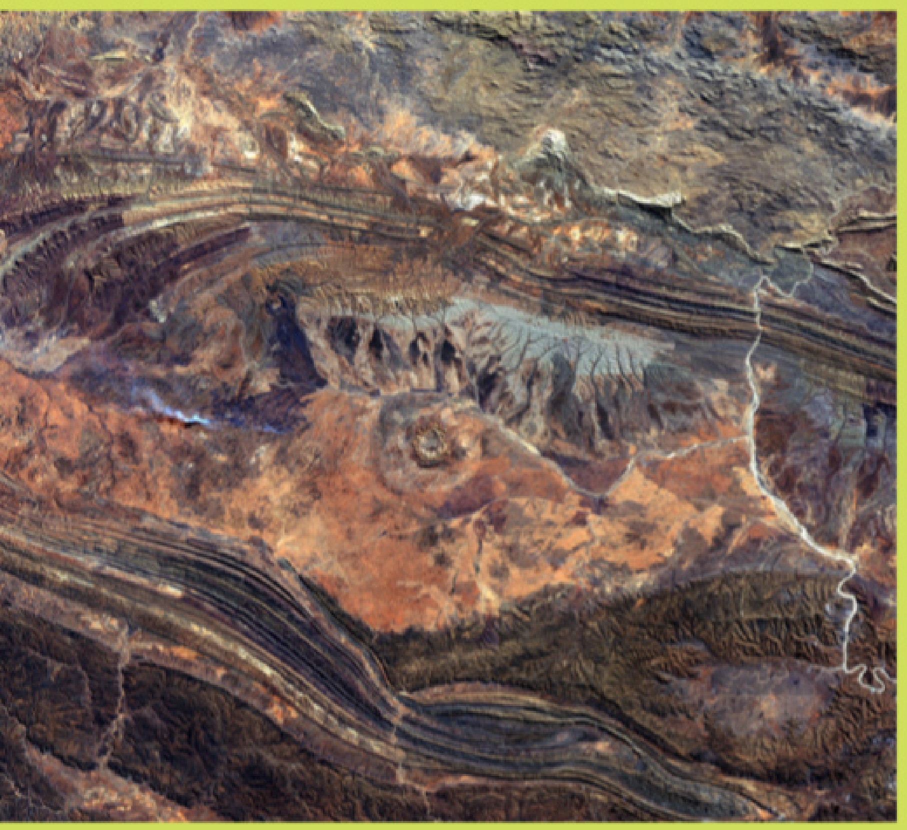
f. Use your smartphone to take videos of your impacts and compare them later.

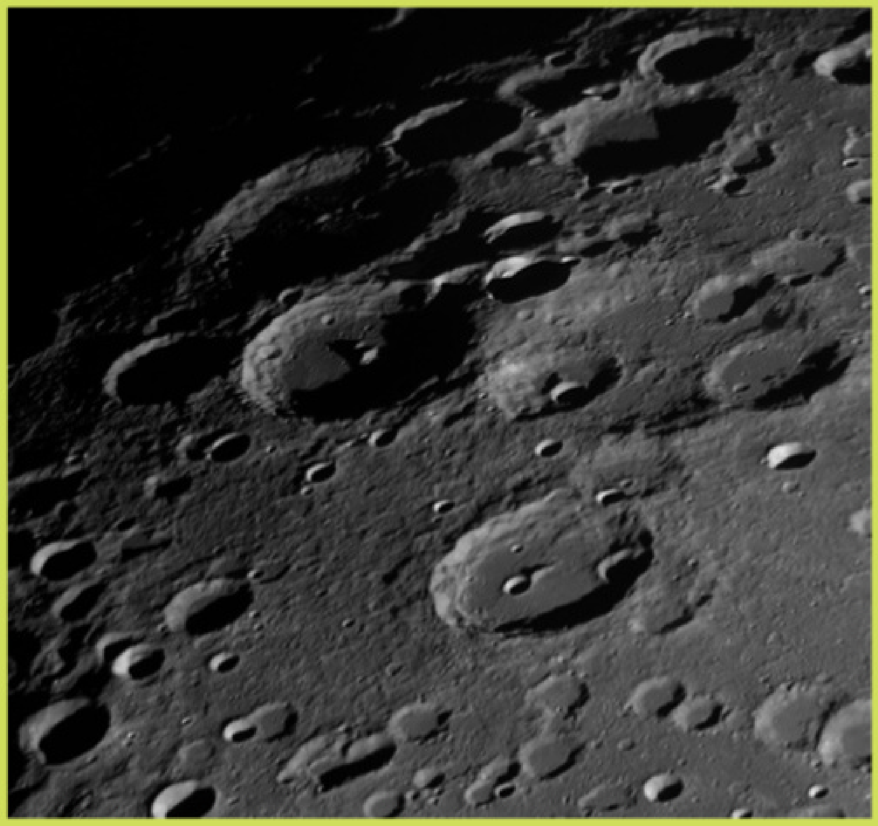
7 Clean up!

FUN FACT

Astronomers have given names to more than 8,000 craters on the Moon.

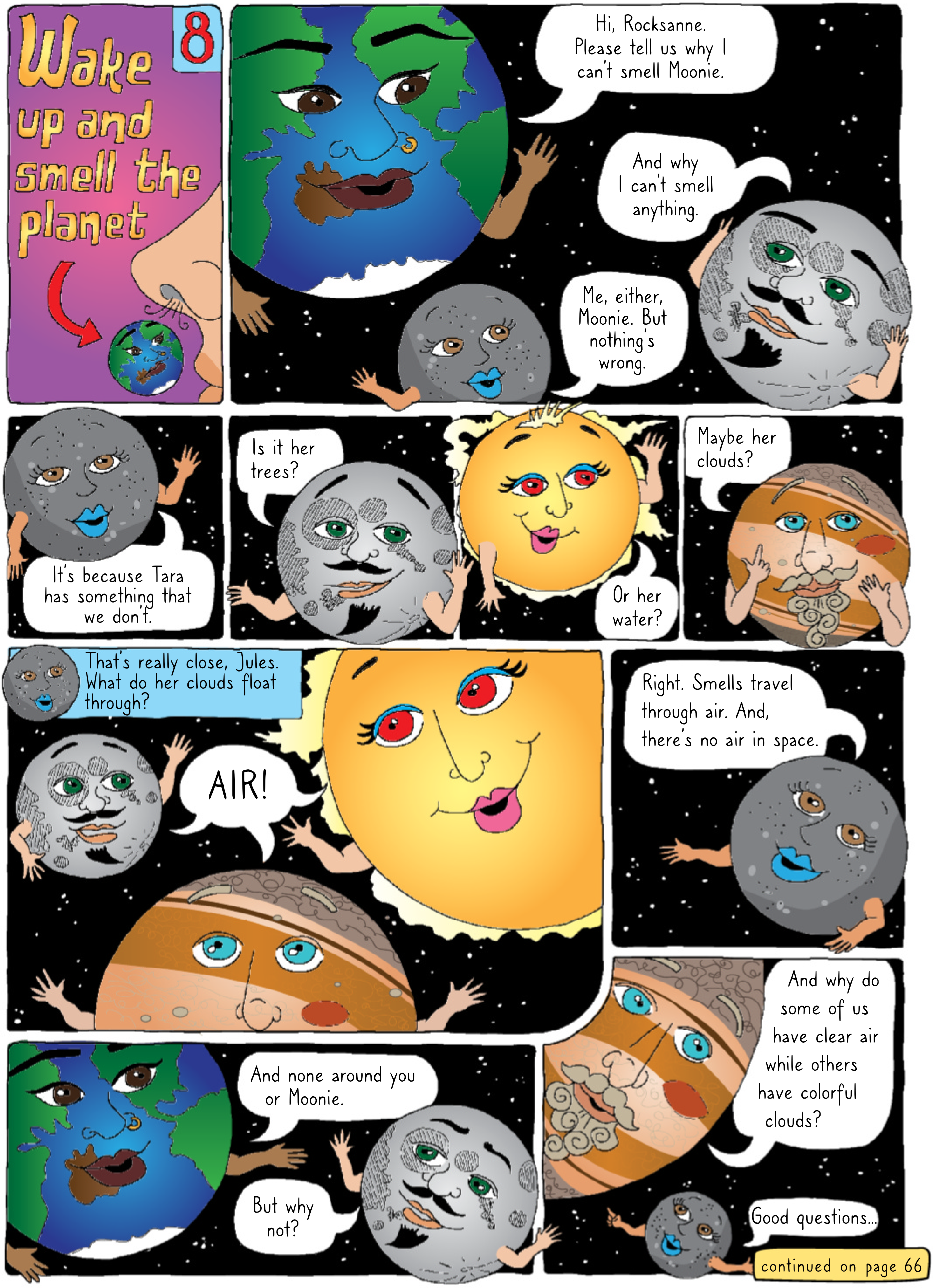
SPRINKLES: NATTAWUT LAKJIT/DREAMSTIME. CRATER ILLUSTRATION: ONYXPRJ/DREAMSTIME





LEFT: If you aim binoculars or a small telescope at the bottom right edge of the Moon (the 5 o'clock position on a clock), you'll see this group of craters. See how many there are in just one small area? Lots of meteorites must have hit the Moon in the past.

DAMIAN PEACH

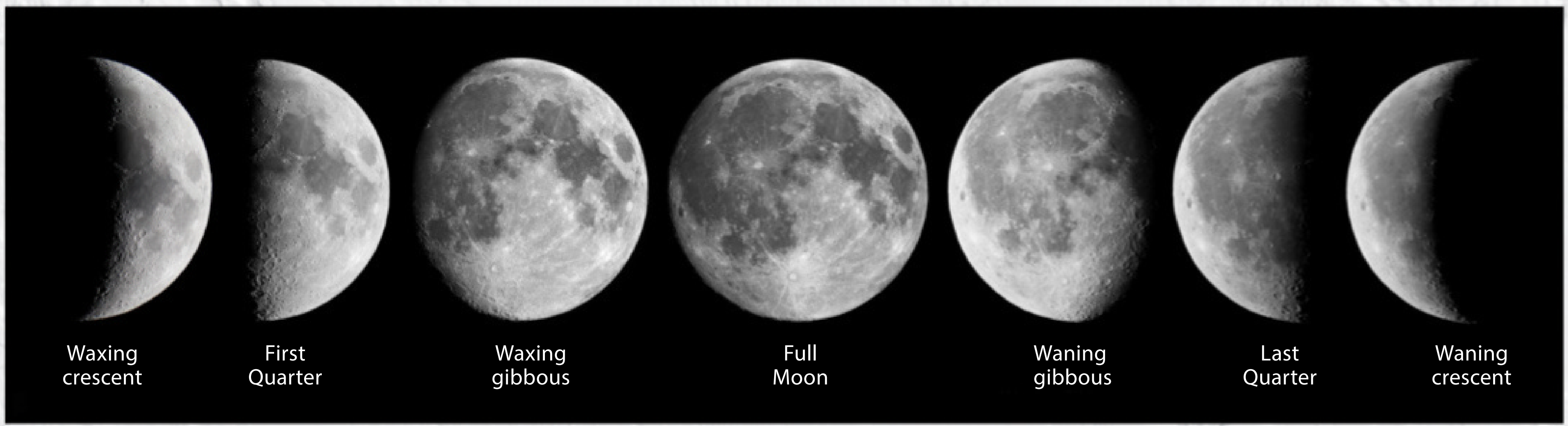

Wake up and smell the planet
8
Hi, Rocksanne. Please tell us why I can't smell Moonie.
And why I can't smell anything.
Me, either, Moonie. But nothing's wrong.
It's because Tara has something that we don't.
Is it her trees?
Or her water?
Maybe her clouds?
That's really close, Jules. What do her clouds float through?
AIR!
Right. Smells travel through air. And, there's no air in space.
And none around you or Moonie.
But why not?
And why do some of us have clear air while others have colorful clouds?
Good questions...

continued on page 66

Track the MOON'S PHASES

by Michael E. Bakich

Make your own Moon Phaser!



SOME PEOPLE LIKE TO LOOK AT THE MOON. They use their eyes, binoculars, or telescopes to pick out details on it. Other people like to look at fainter things, like galaxies. For those objects, moonlight is bad. They want to look when the Moon isn't in the sky. Whichever type of person you are, it's handy to know the Moon's phases. Building this device will let you keep track of them.

WHAT YOU'LL NEED!

☐ Scissors
☐ Razor knife
☐ File folder
☐ Rubber cement

FROM TOP: JAMIE COOPER; RPRONGJAI/DREAMSTIME

Putting it together

1 Make a copy of p. 60 and 61 from this magazine.

2 Brush rubber cement all over the back of the pages.

3 Open a file folder, lay it flat, and spread rubber cement all over one side of it. Let the cement on the pages and the file folder dry completely before you continue.

4 Lay the pages on the file folder, putting the cemented sides together. Gently rub the paper once it's in place to smooth out any wrinkles or bubbles.

5 Cut out the three circles (front, back, and dial) with scissors. Cut carefully around the hanging tab on the front piece, so you can hang the Moon Phaser on a hook or corkboard.

6 Ask an adult to help you with this step: Using a razor knife, cut along the dashed lines on the front piece. Bend the flaps up a little — they will hold the dial in place.

7 Brush rubber cement all over the blank sides of the front and back pieces. But don't put any near the flaps you just cut.

8 When the rubber cement dries, put the front and back pieces together. Line up the edges so your Moon Phaser is nice and round.

9 Carefully slide the dial into the three flaps on the front piece. Make sure the fit isn't too tight. You will be changing the dial's position often.

How to use your Moon Phaser (This is the easy part!)

1 Look at the Full Moon tables on the back piece and find the date of Full Moon for the year and the month that you're interested in.

2 Turn the dial so that the date of Full Moon appears under the Full Moon symbol on the Moon Phaser.

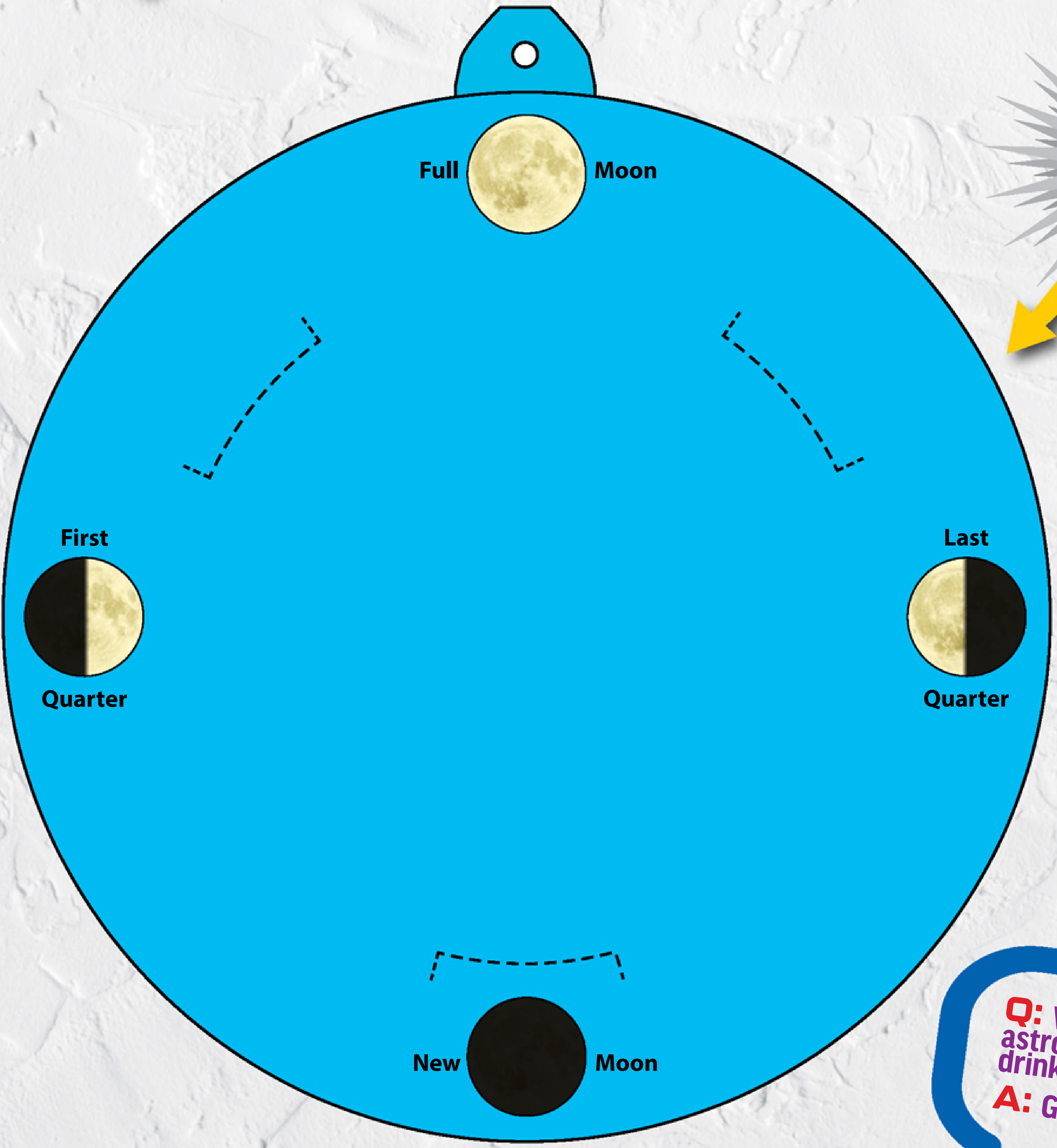
3 Read off the dates of the other phases, which appear near their symbols.

RUBBER
CEMENT

IMPORTANT NOTES

Do not use white glue in place of rubber cement. The pages will become badly wrinkled.

The Moon Phaser uses the average time between Full Moons, about 29½ days. So, even in just one month, it can be a little bit off. Be sure to reset it every time a new month comes around.

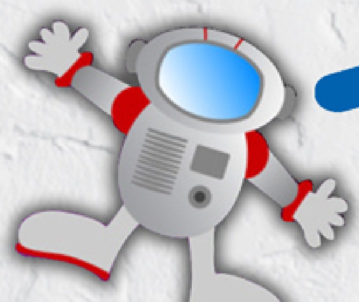

Full Moon
First Quarter
Last Quarter
New Moon

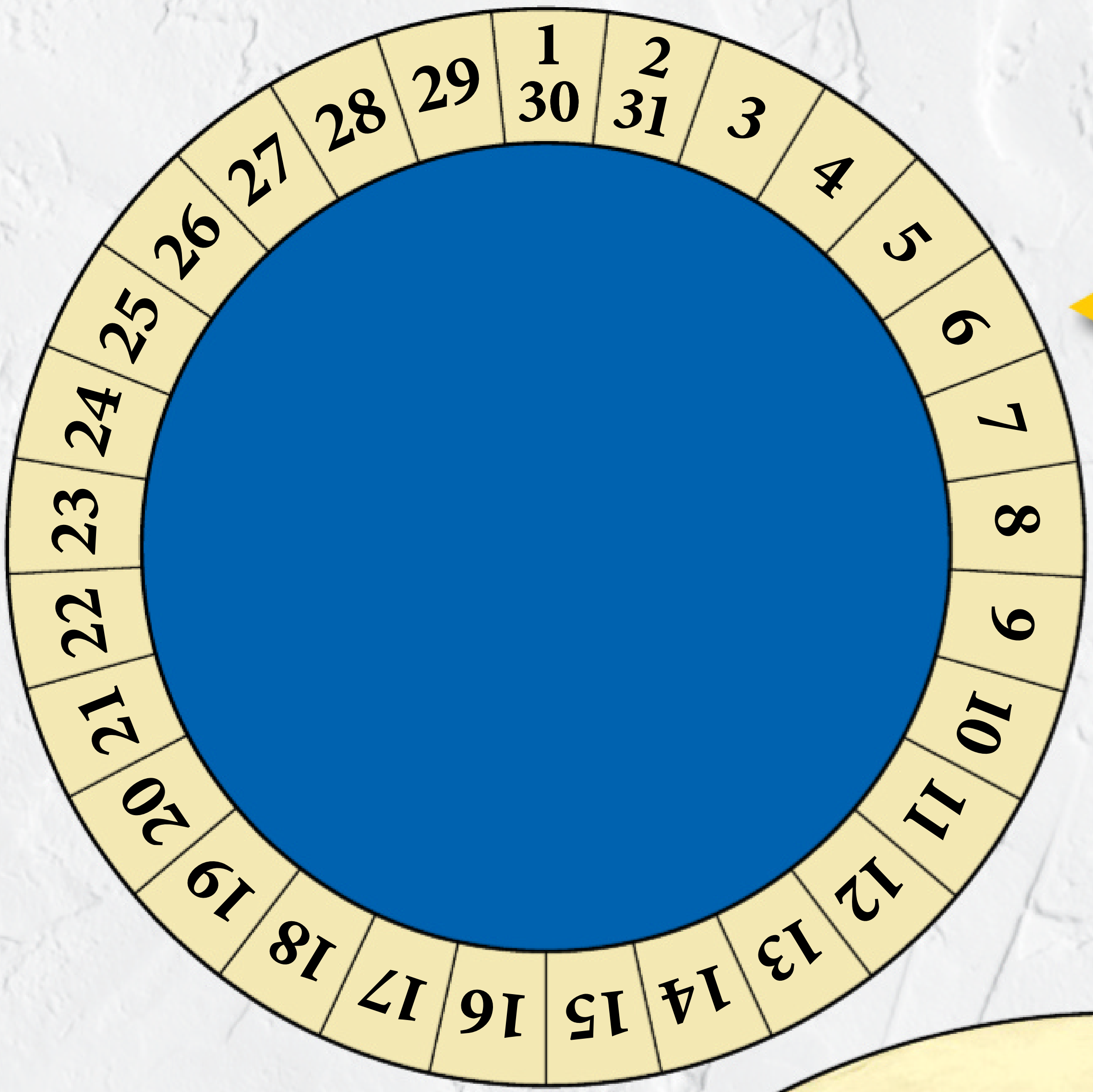
FRONT

Be careful when you're making the three cuts on the dashed lines.

Q: What's an astronaut's favorite drink?

A: Gravi-tea!



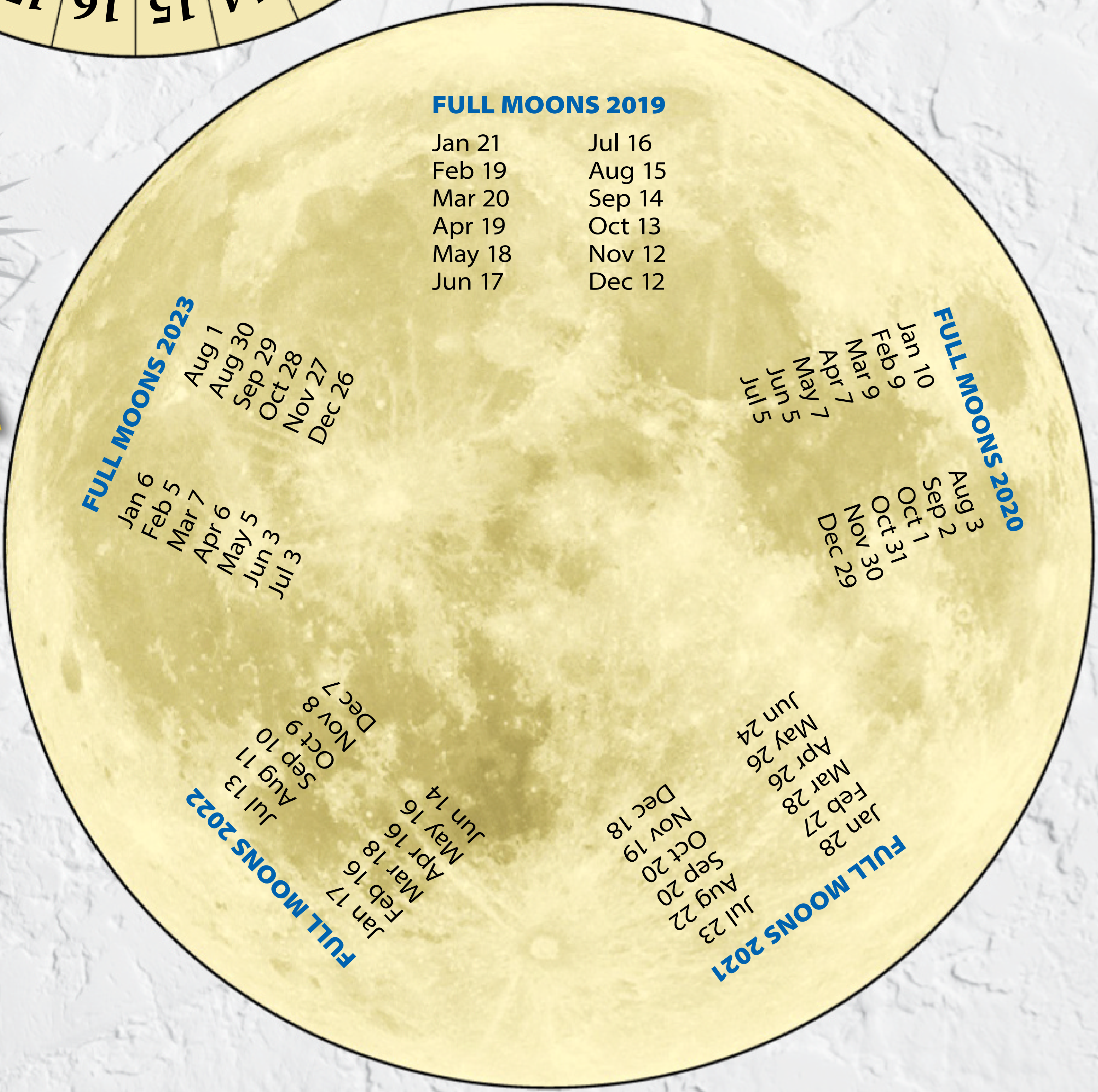


DIAL

Place this dial in the center of the front piece, under the flaps.

BACK

Glue the back of this piece to the back of the front piece.



FULL MOONS 2019

Jan 21
Feb 19
Mar 20
Apr 19
May 18
Jun 17
Jul 16
Aug 15
Sep 14
Oct 13
Nov 12
Dec 12

FULL MOONS 2020

Jan 10
Feb 9
Mar 9
Apr 7
May 7
Jun 5
Jul 5
Aug 3
Sep 2
Oct 1
Oct 31
Nov 30
Dec 29

FULL MOONS 2021

Jan 28
Feb 27
Mar 28
Apr 26
May 26
Jun 24
Jul 23
Aug 22
Sep 20
Oct 20
Nov 19
Dec 18

FULL MOONS 2022

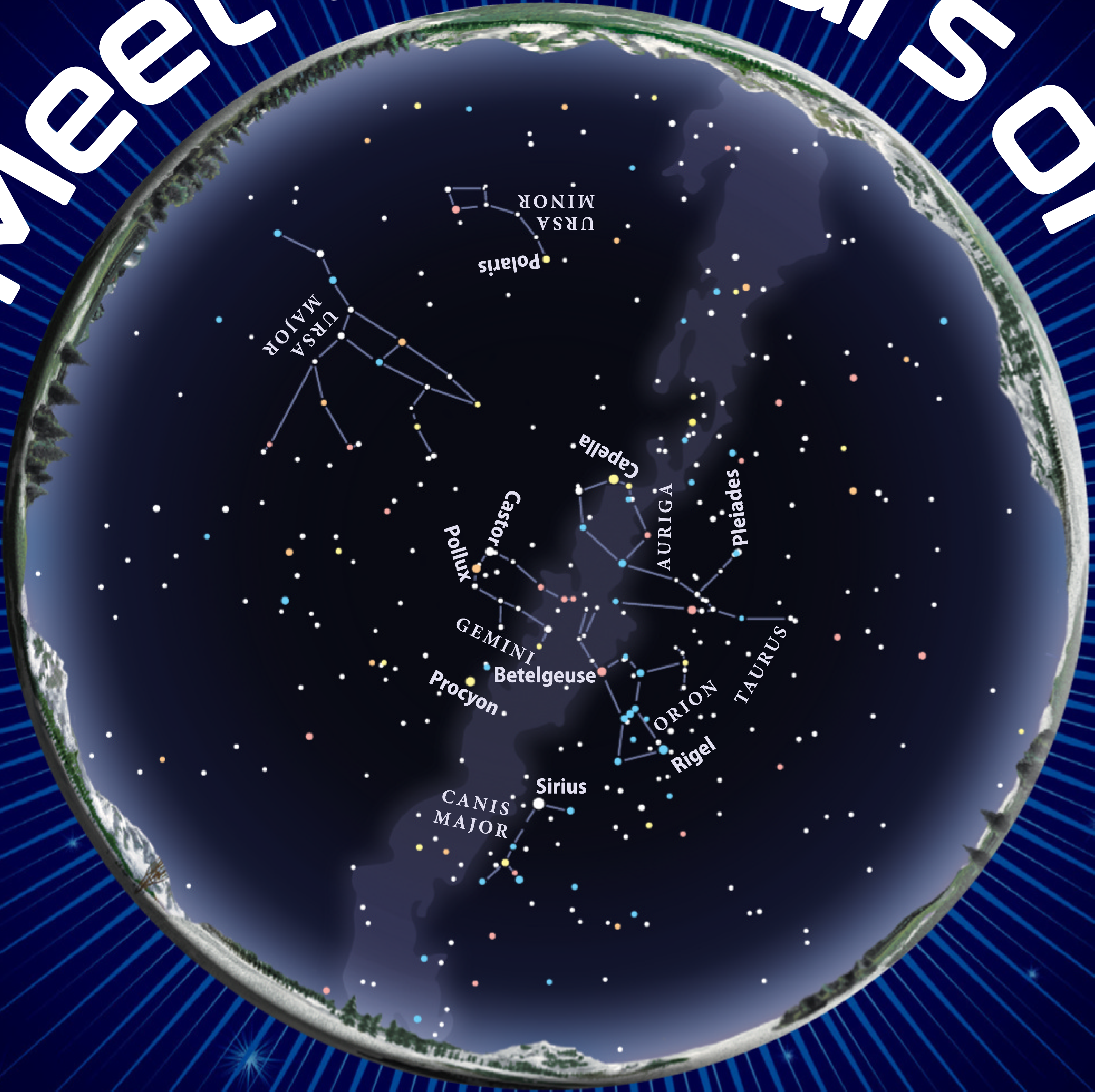
Jan 17
Feb 16
Mar 18
Apr 16
May 16
Jun 14
Jul 13
Aug 11
Sep 10
Oct 9
Nov 8
Dec 7

FULL MOONS 2023

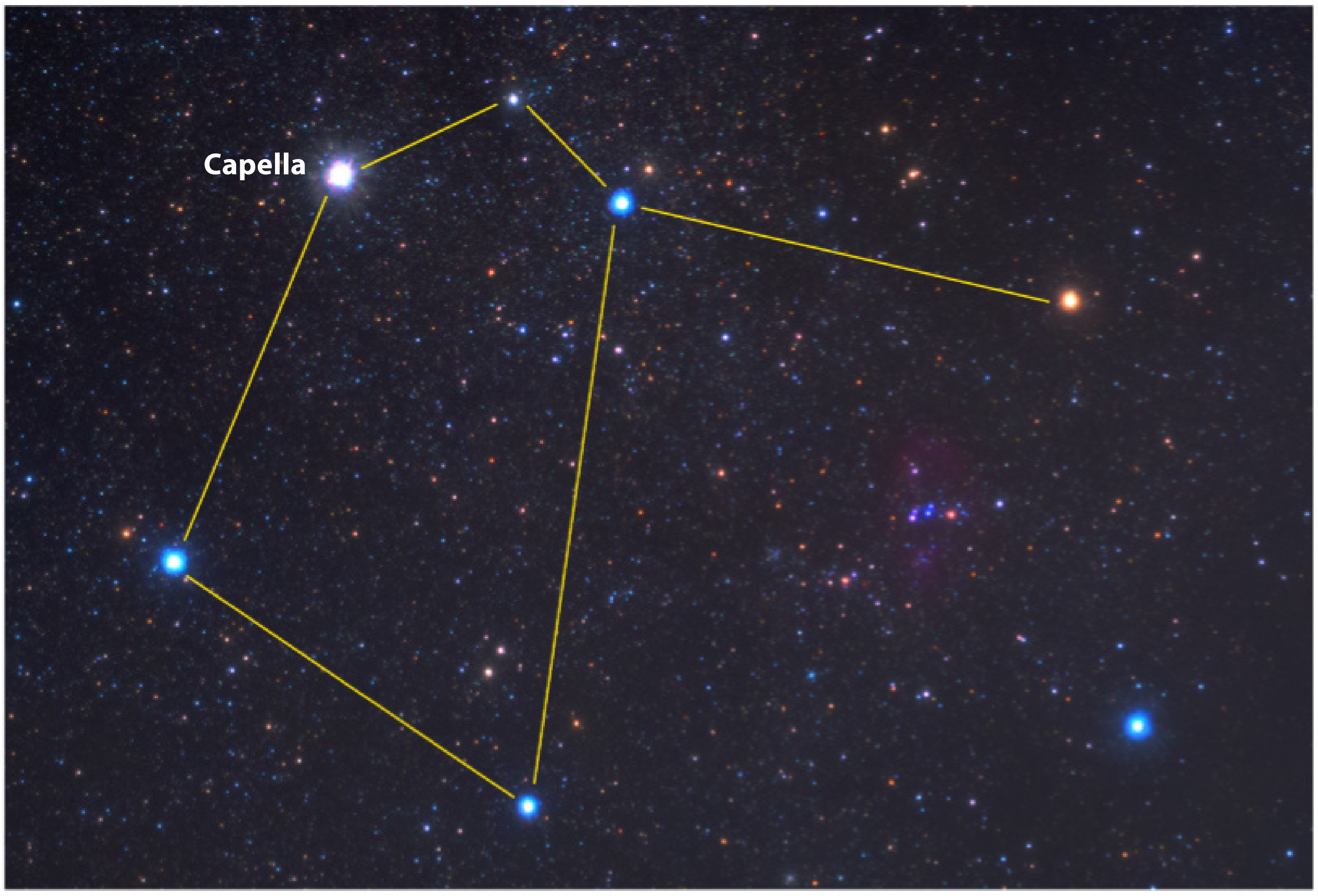
Jan 6
Feb 5
Mar 7
Apr 6
May 5
Jun 3
Jul 3
Aug 1
Aug 30
Sep 29
Oct 28
Nov 27
Dec 26

ASTRONAUT: DANIELFELA/DREAMSTIME. RUBBER CEMENT: GLOBAL NASCO

Meet the stars of WINTER


URSA MINOR
Polaris
URSA MAJOR
Capella
AURIGA
Pleiades
Castor
Pollux
GEMINI
Betelgeuse
Procyon
ORION
TAURUS
Rigel
Sirius
CANIS MAJOR

by Raymond Shubinski



The constellation Auriga is easy to see once you find its brightest star, Capella. The word *Capella* means "mother goat." Look just to the right of that star for three fainter ones making a triangle. Those are the kids. TONY HALLAS

OUT OF ALL THE SEASONS, winter has the most beautiful stars — because they're the brightest.

One nice thing about the winter is that the Sun sets early, so you don't need to stay up late to look at the sky. It may be cold outside, but there's so much to see that you won't notice. In the winter, you'll see five — if you're in the right place, maybe even six — of the 10 brightest stars in the night sky.

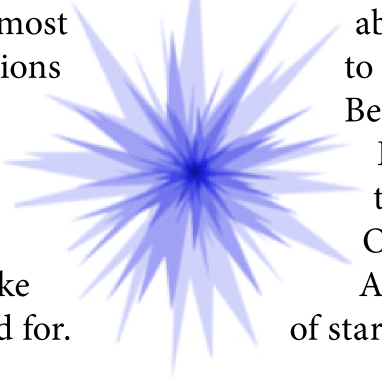
About an hour after sunset, Ursa Major the Great Bear is low in the northeast. That's the constellation the Big Dipper is in. The Dipper was so low in the fall that trees and houses may have blocked your view of it. Now it's standing on the end of its handle. Once you find it, you also can find the directions.

Winter has the brightest stars of any season. Orion the Hunter rules the evening sky this time of year. Can you make an hourglass shape from its seven brightest stars? The three stars of the Hunter's belt point down to Sirius, the brightest star in the sky, and up to the Pleiades, part of Taurus the Bull. To Orion's upper left is Gemini, and above Orion you can find Auriga. *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

Draw a line between the two stars at the end of the Dipper's bowl. This line points the way to Polaris the North Star, which is part of Ursa Minor the Bear Cub. If you've tried to find the constellations in any other season, you know that sometimes it's hard to imagine some of these animals and pictures. So, look at Ursa Minor as the Little Dipper. Polaris is the end of its handle, and the rest of it curves toward the Big Dipper. You'll need to look from a dark place because four of the Bear Cub's seven stars are really dim.

Pictures of the bears in the sky show them with long stretched-out tails, which make the handles of each dipper. But bears on Earth don't have long tails. There are many stories explaining why these sky bears do. One tells that the Greek god Zeus turned a beautiful young woman and her child into bears to hide them from his jealous wife, Hera. When that didn't work, Zeus saved them by grabbing both bears by their short tails and throwing them into the sky, stretching out the bears' tails in the process.

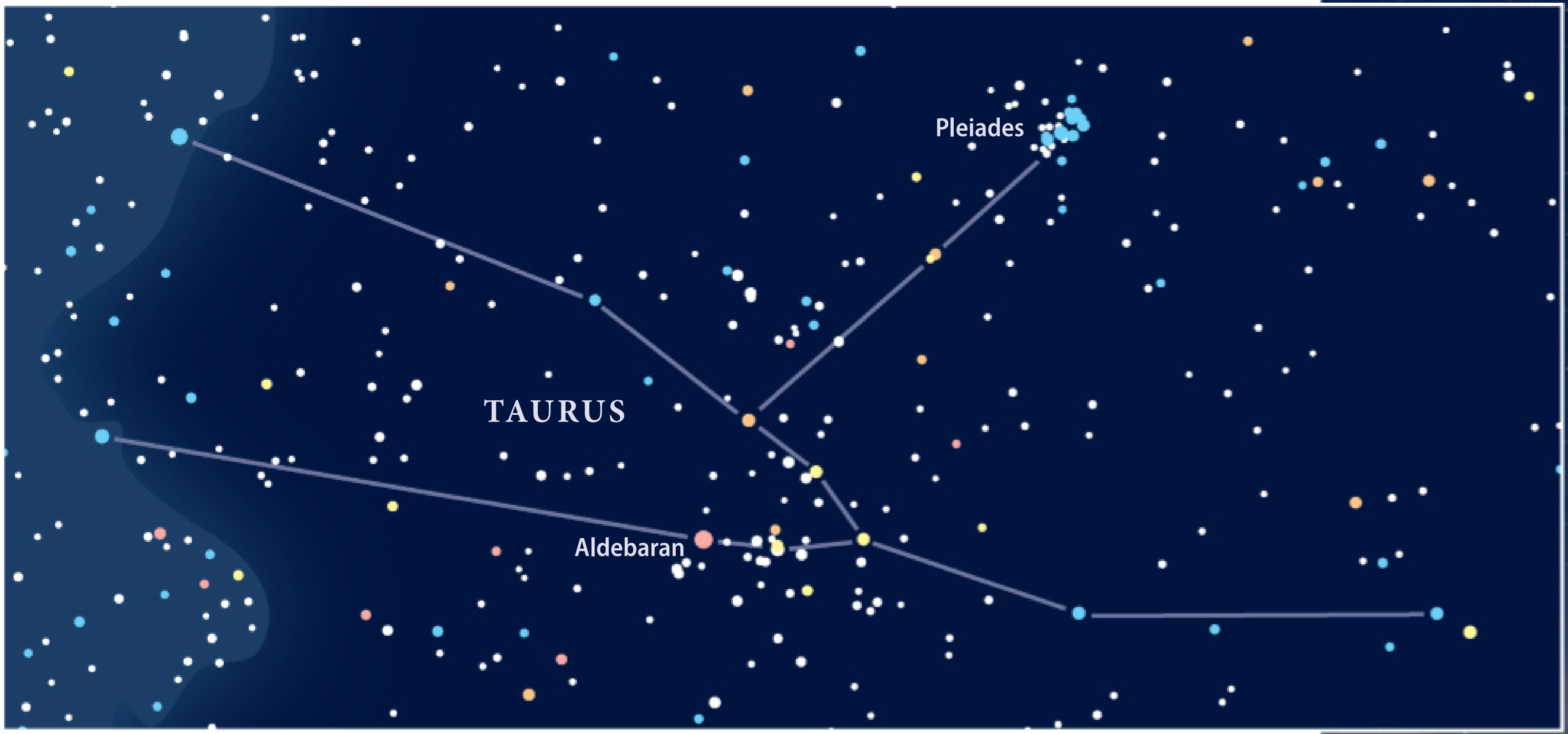
Turning to the south, you can see one of the most amazing constellations in the night sky, Orion the Hunter. Many constellations, like the bears, don't look like what they're named for. But it's easy to trace a man using Orion's seven bright stars. Three stars in a short row are the belt of this mighty hunter. Up and slightly to the left of the belt is Betelgeuse, the 11th-brightest star in the night sky. It has a copper-red color.



It's also old. Betelgeuse is close to the end of its life, so it has become gigantic. Well, *gigantic* doesn't quite cover it. Our Sun is gigantic; more than a million Earths could fit inside it. But Betelgeuse is so huge that 3 billion Suns could fit inside it.

One day, probably thousands of years from now, it will explode. But it's so far away that if it blew up tonight, it would be 700 years before we'd know about it. The star to the right of Betelgeuse is Bellatrix. These two stars mark Orion's shoulders. A rather dim pair of stars lies between

OPPOSITE PAGE BACKGROUND: NATALIA KUCHUMOVA/DREAMSTIME. STARBURST: ILLIA HRYHORIEV/DREAMSTIME. CHILDREN: ANNA VITEEVA/DREAMSTIME



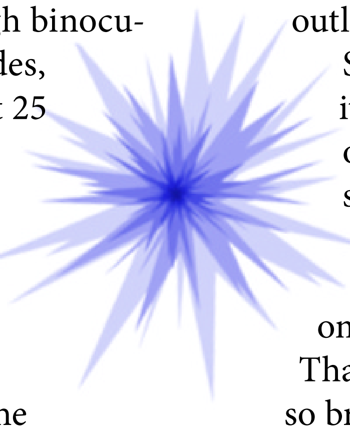
Taurus the Bull's head is shaped like the letter V. Its brightest star is Aldebaran, which looks red. At the top right of this star chart, the Pleiades — also called the Seven Sisters — ride on the Bull's back. *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

them, which represents the hunter's head.

Below the belt and to the left is the star named Saiph; to the right is Rigel. These two stars are Orion's feet. Blue-white Rigel is the seventh-brightest star in our sky, but if you could see all stars from the same distance, Rigel would look the brightest.

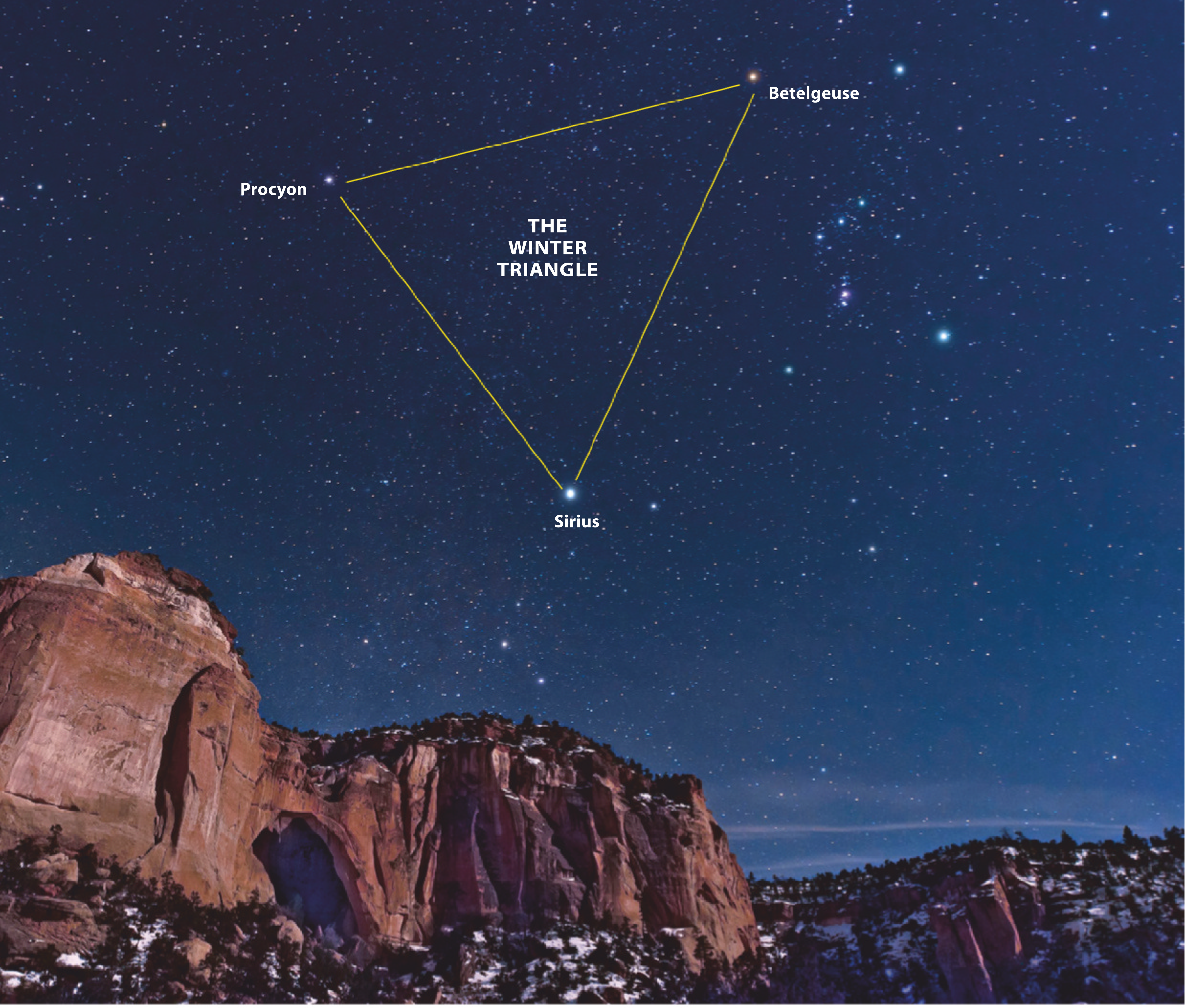
Hanging from the Hunter's belt is his sword. Near the middle of the sword is an amazing object called the Orion Nebula. *Nebula* is a Latin word that means "cloud"; the Orion Nebula is a cloud of dust and gas in space. If you look at it through binoculars, you'll see a fuzzy patch of light. A small telescope shows that the cloud is glowing. The Orion Nebula is where new, hot stars are being born.

After you find Orion, you can use it to guide you to other stars and constellations. Draw a line up through Orion's belt, and you'll come to Aldebaran, the bright red eye of Taurus the Bull. Stars shaped like the letter V mark the bull's head. Keep your line going, and you'll run into the Pleiades, sometimes called the Seven Sisters. A story tells that Orion fell in love with all seven sisters. Zeus put them on the back of Taurus to keep them safe. If your sky is dark and clear, you should be able to see all seven stars, although some people — mainly adults, whose eyes aren't as good as children's — might only be able to see five or six. But if you look through binoculars at the Pleiades, you could count 25 or more stars.



When you're done looking at Taurus and the Pleiades, draw a line through Orion's belt in the other direction to find Sirius, the brightest star in the night sky. Sirius is called the Dog Star because it's part of Canis Major, the big hunting dog of Orion. If you have a good imagination, you can see the outline of a dog, with Sirius as a diamond on its collar. Sirius is one of the closest of all stars, only about 50 trillion miles away. (Yes, in astronomy, that's really close!) That's one reason it looks so bright. It's also twice as big as our Sun.

Next, look above Canis Major for another bright star. It's Procyon, the eighth-brightest nighttime star.



Three of this season's brightest stars make a figure called the Winter Triangle. Can you see the difference in their colors? JOHN A. DAVIS

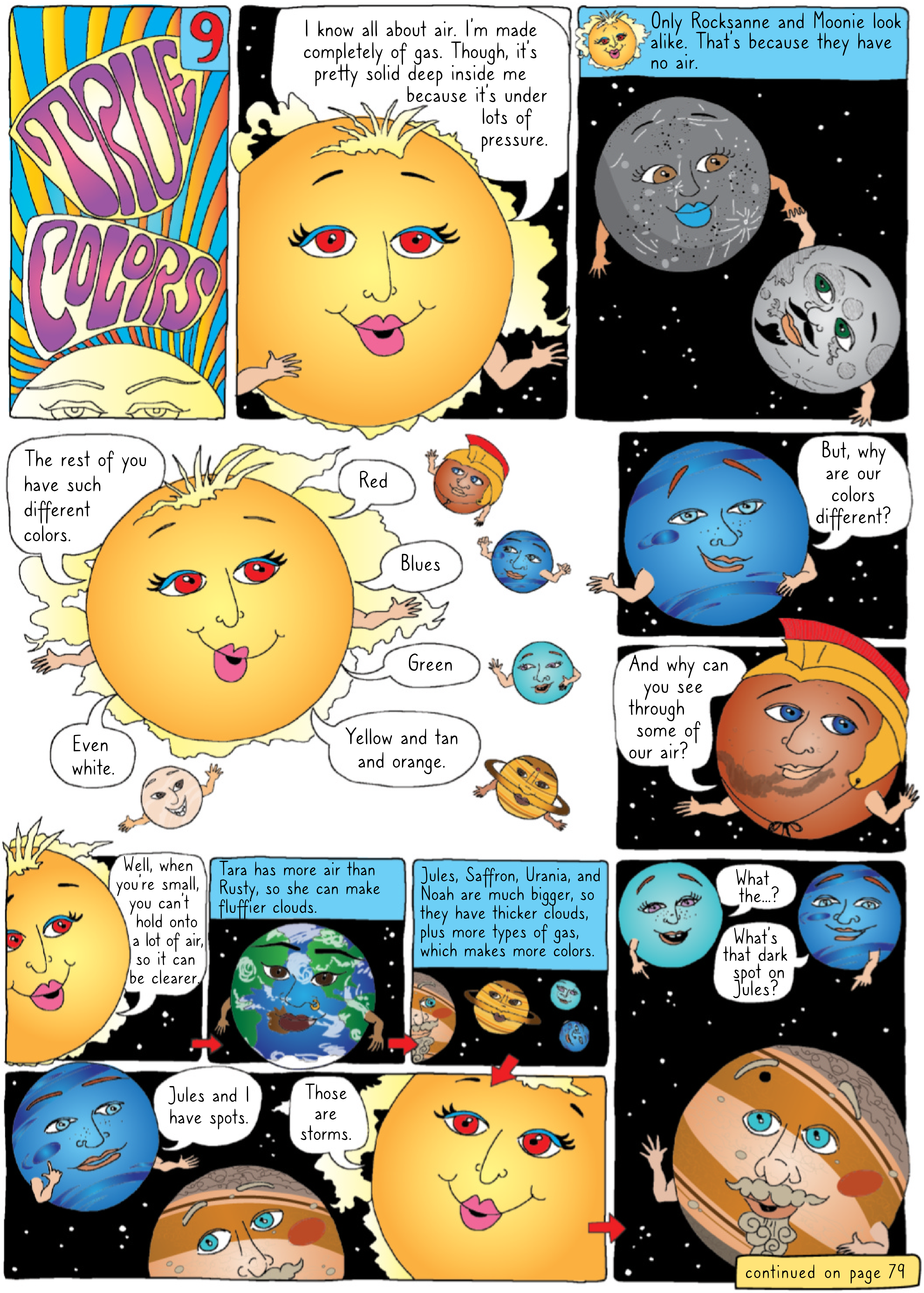
Once you find Betelgeuse, Sirius, and Procyon, you've found the Winter Triangle. It's not a constellation, just a figure made of bright stars that's easy to see.

If you live in a southern state like Texas, Arizona, or Florida, you can also see the night sky's second-brightest star, Canopus, in the constellation Carina. You'll find this star below Sirius and close to the horizon.

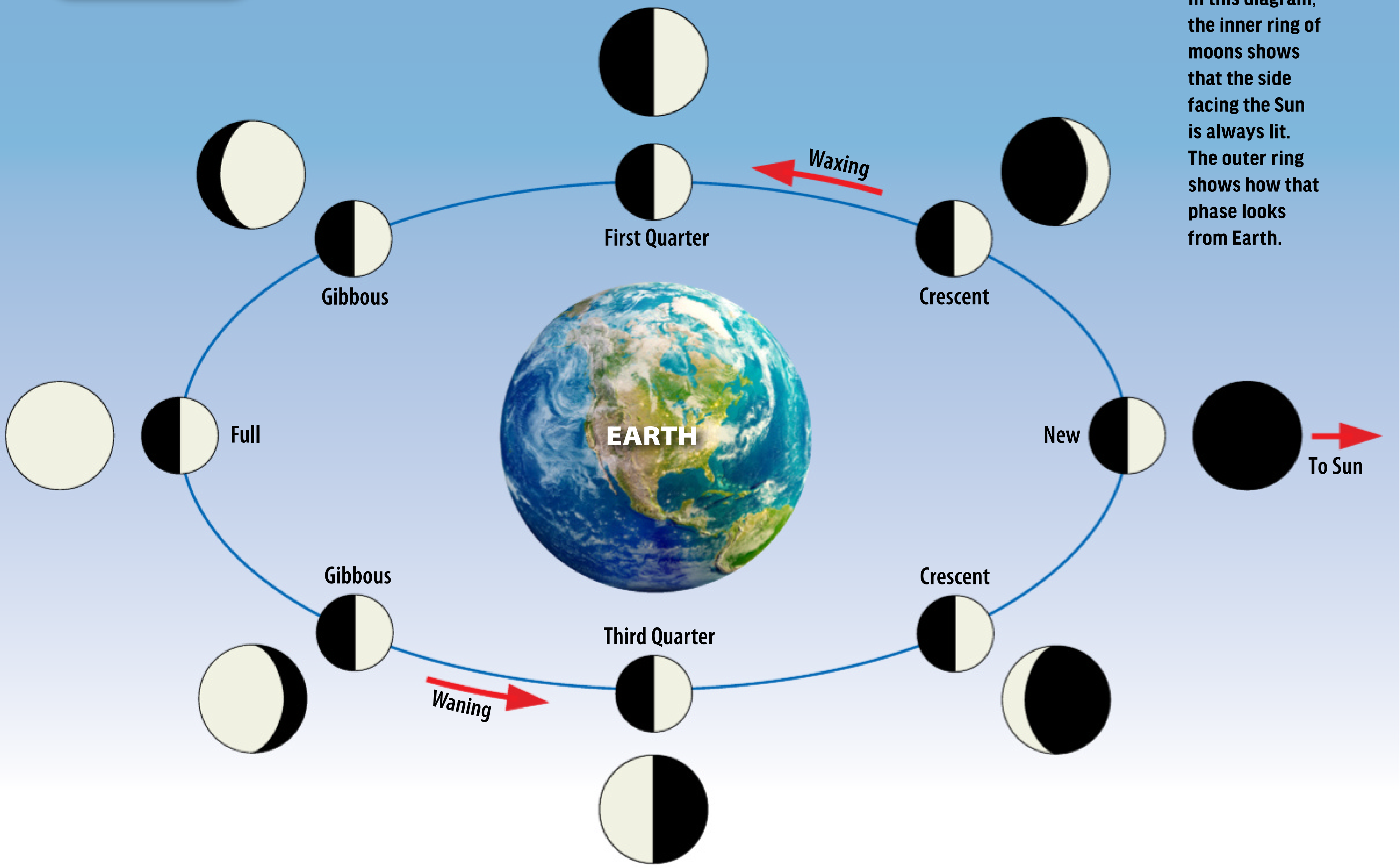
If you look high above Orion's head, everyone can find Capella in the constellation Auriga. This yellow star is No. 6 in brightness. Auriga is supposed to be a man driving a chariot. He holds a goat in his hands. The word *Capella* means "mother goat." And if you look near that bright star, you'll see three fainter stars that are her kids. Baa!

To the east of Capella, you'll find two bright stars named Castor and Pollux. They are the twin stars of the constellation Gemini the Twins. The twins are very skinny, and their bodies point down to Orion. Even though the stars are supposed to be the heads of the twins, they don't look the same. Pollux is an older yellow star while Castor is a huge, young, white star.

As winter continues, the season's constellations move toward the west. If you go outside a couple of hours after sunset, you'll see that a few spring stars and constellations are starting to peek above the eastern horizon.


9
TRUE COLORS
I know all about air. I'm made completely of gas. Though, it's pretty solid deep inside me because it's under lots of pressure.
Only Rocksanne and Moonie look alike. That's because they have no air.
The rest of you have such different colors.
Red
Blues
Green
Yellow and tan and orange.
Even white.
But, why are our colors different?
And why can you see through some of our air?
Well, when you're small, you can't hold onto a lot of air, so it can be clearer.
Tara has more air than Rusty, so she can make fluffier clouds.
Jules, Saffron, Urania, and Noah are much bigger, so they have thicker clouds, plus more types of gas, which makes more colors.
What the...?
What's that dark spot on Jules?
Jules and I have spots.
Those are storms.

continued on page 79



In this diagram, the inner ring of moons shows that the side facing the Sun is always lit. The outer ring shows how that phase looks from Earth.

SEE HOW THE MOON SPINS

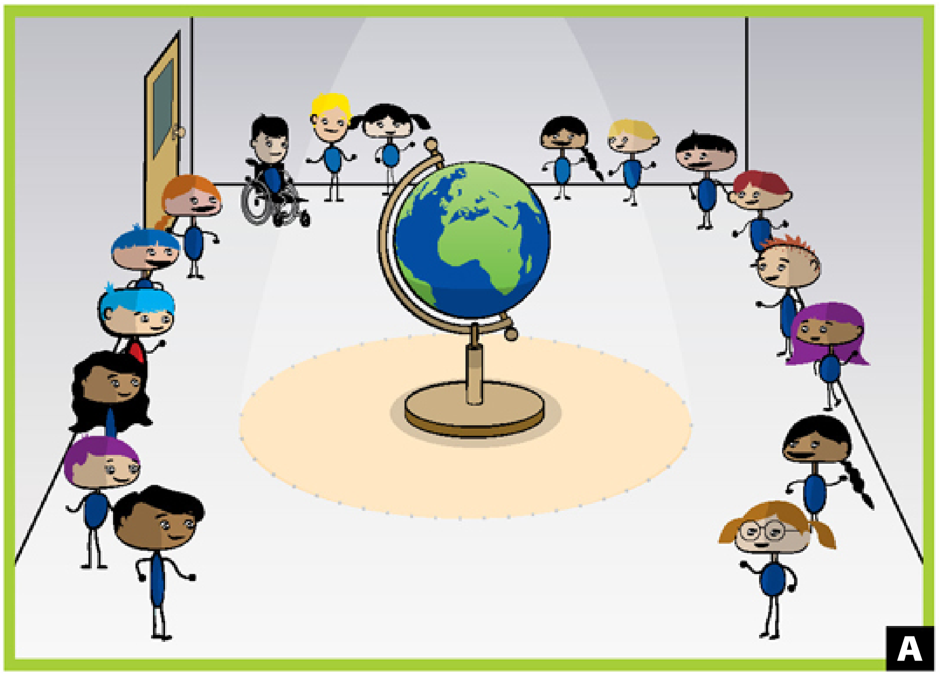
by Michael E. Bakich

MOON ILLUSTRATION: *ASTRONOMY*: KELLIE JAEGER. EARTH: 7XPERT/DREAMSTIME

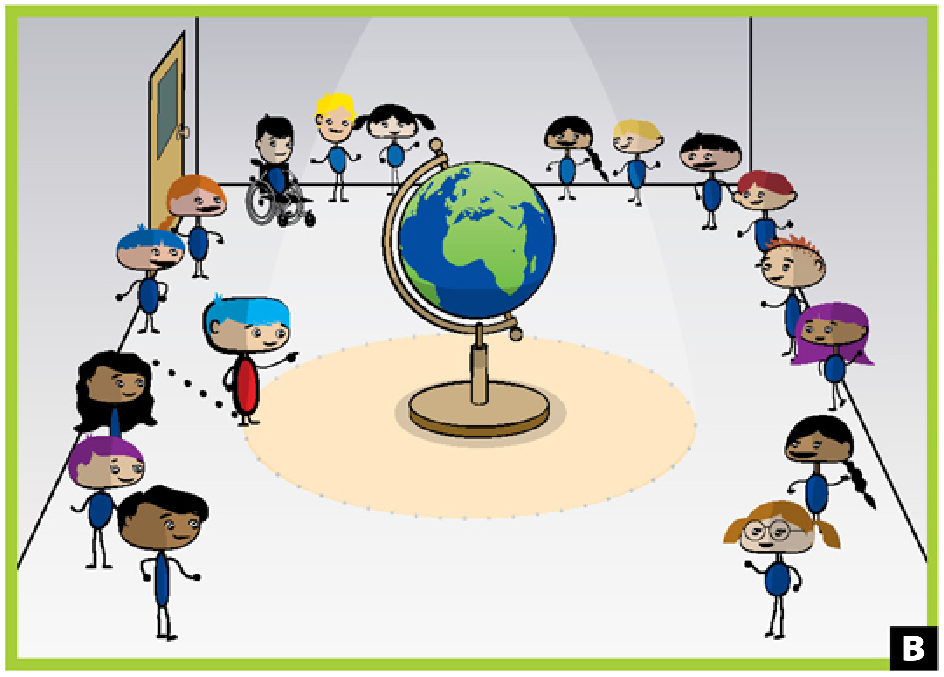
PEOPLE HAVE WATCHED THE MOON for thousands of years. In all that time, they have seen only one side of it. The only exceptions were the 27 Apollo astronauts who orbited the Moon during their missions. (Space satellites also photographed the Moon's farside, so a lot of people have seen pictures of it.)

The Moon keeps one face pointed to Earth because the gravity of these objects works together in a special way. So, the Moon's nearside always faces us, and its farside always points away from us. That means the Moon doesn't spin, right? Wrong! For the same half of the Moon to face us all the time, the Moon has to spin once for each trip it makes around Earth.

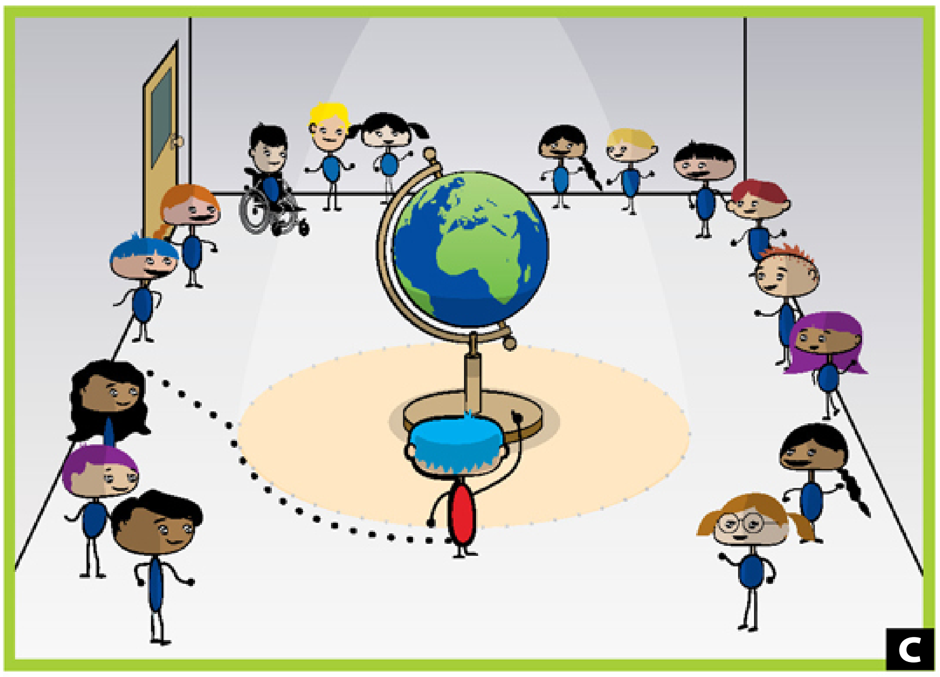
Does this sound wrong to you? If so, you're not alone. Many people think the Moon doesn't spin. But you can do a simple demonstration to show that it does.



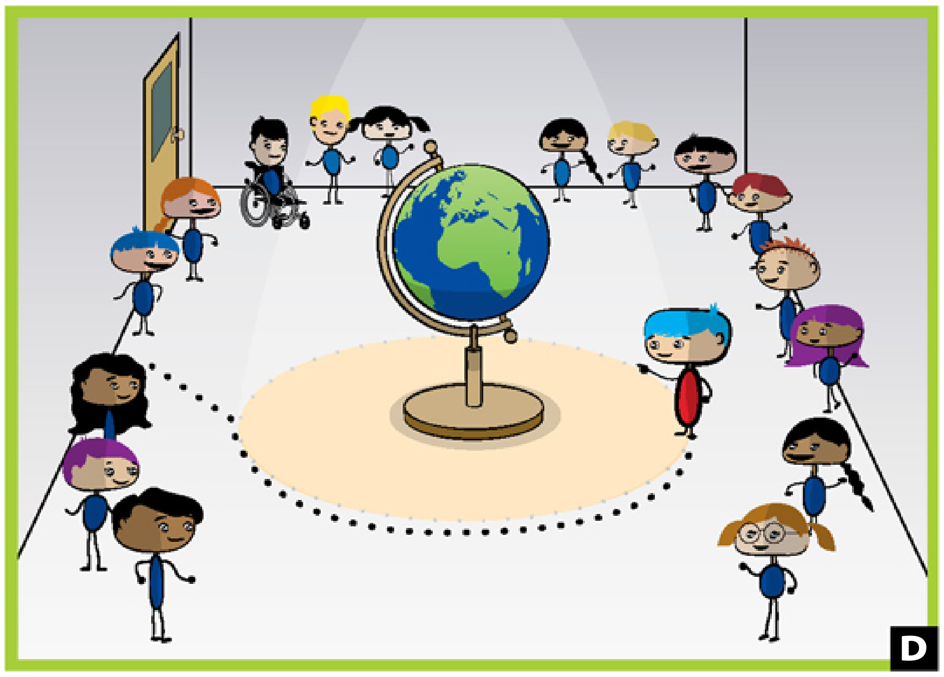
If you're showing how the Moon spins in a classroom, select something (or someone) to be "Earth." It should go in the middle.



Pick someone to be the "Moon." Everyone else can be other planets, comets, or even distant stars.



Have the "Moon" slowly orbit "Earth." The "Moon" should keep his or her face pointed toward "Earth," just like the real Moon.



After the "Moon" goes halfway around "Earth," talk about what happened. Did the "Moon" spin?

ASTRONOMY: KELLIE JAEGER

What to do

1 Place "Earth" in the middle of a room. This demonstration works really well in a classroom.

2 Pick someone to be the Moon. It could be you, a friend, or one of your classmates.

3 Choose a starting point. Have the "Moon" stand there facing "Earth." Notice the wall the "Moon" is facing.

4 If you do this in a classroom, have the other students stand near the walls. They will be the distant stars.

5 Have the person playing the "Moon" start to move in a circle slowly around "Earth." And, just like the real Moon does, ask the "Moon" to always keep their face pointed toward "Earth." They can even point to "Earth" as they go around it.

6 Have the "Moon" stop after they go halfway around "Earth." Look carefully at how the "Moon" is standing. Did the "Moon" spin?

To answer this, notice the wall the "Moon" is facing in picture D above. Is it the same wall as in picture B? It's not, is it? What happened? For your "Moon" to now be facing the opposite wall, they had to spin halfway around as they orbited halfway around Earth.

WHAT YOU'LL NEED!

☐ Something to play Earth
(It could be an Earth globe, a pillow, or someone sitting in a chair. Whatever you choose, it's "Earth.")

Q: How do you like the new restaurant on the Moon?

A: The food is great, but there's no atmosphere.

ALIEN: DANIELFELA/DREAMSTIME

Astronomy

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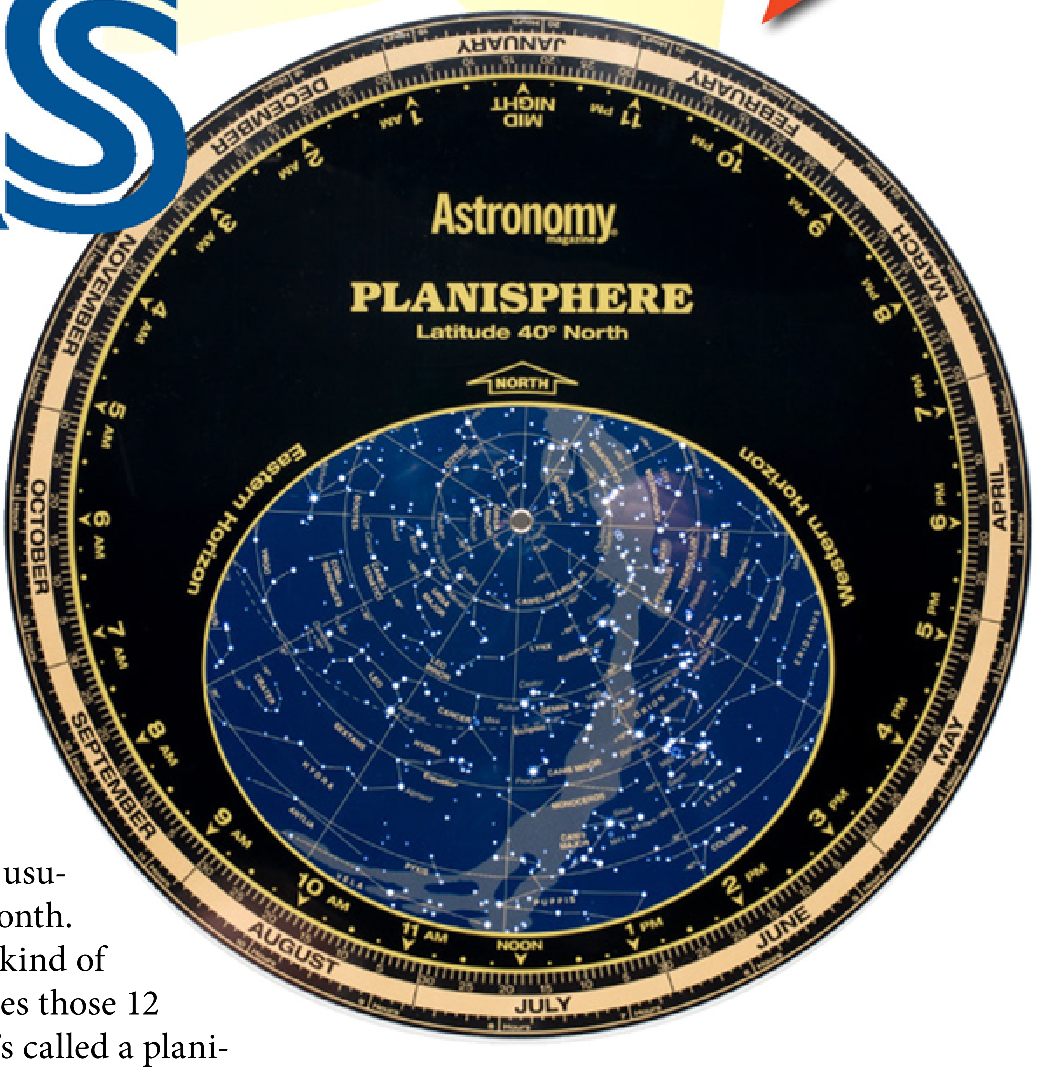
P35018

Chart THE STARS

by Raymond Shubinski



This planisphere is a great way to learn the sky and to know which stars will be up at any time on any day of the year. You'll find it online at MyScienceShop.com.

ASTRONOMY: WILLIAM ZUBACK

ON A DARK NIGHT, the sky can look like a jumbled mess. The stars don't seem to have any order. But long ago, people made up pictures we call constellations to keep track of the stars. And we still use them today.

There are 88 constellations that cover the sky. Some are famous, like the Great Bear (which contains the Big Dipper), Orion the Hunter, and Taurus the Bull. But, how can you figure out which one is which?

Like driving somewhere in a car, you need a map. You can use a road map at any time, and it's good for years. But the sky changes some with each hour and with each season. If you look at the sky at 10 P.M. on the first day of spring, and then again at 10 P.M. on the first day of fall, you'll see different constellations. In the spring, you would see Leo the Lion high in the south. Six months later, Pegasus the Flying Horse would be in the same place.

The sky changes like this because Earth is traveling around the Sun. As we ride along with our planet, we look at parts of space that have different stars. So, you need different maps for different times of the year, usually one for each month. But there's a special kind of star chart that replaces those 12 maps with just one. It's called a planisphere.

A planisphere is made of two parts. The bottom piece is a circular star map. The top piece is called the "mask." It has a clear window that shows some of the stars and hides the others. The two parts are held together at the center so you can spin or rotate the mask.

The names of the months are printed around the outer edge of the bottom piece. Each month is divided into days. The 24 hours of the day are printed on the edge of the mask. By turning that part, you can line up any time with any date.

How to use the planisphere

To use the planisphere, choose a date and time. Let's use April 20 at 9 P.M. Rotate the mask until the 9 P.M. arrow is pointing at April 20. "Eastern Horizon," "Western Horizon," and "North" are printed around the edge of the window. (The eastern and western horizons are reversed because to use the planisphere, you have to hold it over your head.)

Hold the planisphere above you so the north arrow points north. Can you find Leo the Lion? He's at the center of the map in the south. Next, look for Gemini

STAR BRIGHTNESSES

You'll notice that stars on the planisphere are several different sizes of dots. The map is made like that because it's the only way to show the differences in star brightness. Big dots are bright stars, and small dots are fainter stars. In the real sky, however, stars all look the same size — just a single point of light. And some of those points are really bright! But did you know that there are billions of stars so faint that you can't see them at all? That's when binoculars and telescopes help. Those instruments have much bigger "eyes" than humans, so they can gather light from much fainter objects than we can see.

the Twins. That group is between Leo and the western horizon. Now look for the constellation Hercules. It's rising near the eastern horizon.

One of the first stars you should find with any chart is the North Star. To find it, turn the planisphere so the "North" arrow is pointing down. The Big Dipper, which is part of Ursa Major the Great Bear, is easy to find high in the north — even though it's upside down. When you find it, use the two stars at the end of the Dipper's bowl to point to Polaris the North Star. Unfortunately, the round metal piece that holds the two parts of the planisphere together is right where the North Star is. But you will see the star in the real sky.

Now set the planisphere to 9 P.M. on October 20. Like before, hold the planisphere so south ("Noon") is down. Now you can see Pegasus the Flying Horse in the center of the map where you saw Leo six months ago. Hercules, which was just rising in the east on April 20, is now setting in the west. Just climbing above the eastern horizon is Taurus the Bull, and Gemini the Twins is nowhere to be seen! Now turn the star map so north points down. Can you see the Big Dipper really close to the horizon?

This simple star map shows Earth's motion around the Sun beautifully. A set of 12 star maps would show the same thing, but would be a lot harder to handle. Now that you know how to set the date and time on the planisphere, try a few for practice. What stars are in the sky at 10 P.M. on your birthday?

A few more details

On Earth, we measure how far north or south we are from the equator with latitude. The *Astronomy* planisphere is set for 40° north latitude, about halfway between the equator and the North Pole. This latitude is in the middle of the United States, so it works well there. But there are lots of places all over the world near 40° north latitude. So, this planisphere also would work in Spain, Italy, Greece, Turkey, China, and Japan. Planispheres are also made for different latitudes and for the Southern Hemisphere.

People usually have two questions about planispheres: "How long are they good for?" and "Why don't they show the Moon and planets?"

All the stars move through space. But because they're so far away from us, the constellations made from those stars take thousands of years to change their shapes. This means that one planisphere is good for a whole lifetime (and a lot longer).

The answer to the second question is that planispheres don't show moving objects. The Moon and the planets are a lot closer than the stars, and they travel around Earth and the Sun. So, to us they change their positions in the sky each day. Trying to show all those positions on a planisphere would be impossible. But you can keep up with their motions by visiting websites like Astronomy.com.

Finally, remember when you use the planisphere outside to hold it so the direction you're looking at is at the bottom. If you're looking north, make sure you turn the map so the "North" arrow is pointing down. Then turn the planisphere to match whichever direction you are looking toward. When you do this, your map will match the part of the sky you want to observe.

Astronomy
PLANISPHERE
Latitude 40° North
NOVEMBER
OCTOBER

THE SKY LOOKS DIFFERENT

When you stand outside looking at the stars, the sky appears to be a huge upside-down bowl over your head with stars scattered from the horizon to overhead. That bowl shape is called a hemisphere, which means "half a sphere." When a hemisphere is squashed down to make a flat map, star patterns near the horizon get stretched out.

Turn the planisphere to 9 P.M. on July 20, and look toward the south near the ground. Do you see the constellation Scorpius? This constellation is spread out on the planisphere compared to what you see in the sky. But it's still in the right place.

STARS: SERGEY YARLYKOV/DREAMSTIME. BOY: PHOTO BY RAYMOND SHUBINSKI

This is what your eye would see during the total part of a solar eclipse.

JENNIFER IUVONE

All about ECLIP

by Mike Reynolds

Q: How does the man on the Moon cut his hair?

A: E-clips it!

THERE WAS A TIME WHEN astronomers could learn a lot from eclipses. Total solar eclipses let them carefully study the Sun's outer atmosphere and map the Moon's edge. Today, eclipses don't give us much new science, but we still look forward to them. Eclipse trips and cruises are big business. Why? Because eclipses are wonderful! Many people would say a total solar eclipse is the greatest sight in nature.

Why do we see eclipses? And what types of eclipses can we see? Because the Sun shines on Earth and the Moon, they cast shadows. But unlike the shadows from the things around us, their shadows have two parts. The penumbra is the lighter outer shadow. The umbra is the dark inner shadow. When the Sun, Earth, and the Moon line up exactly, in that order, an eclipse of the Moon will happen. When they line up exactly with the Moon in the middle, there will be an eclipse of the Sun.

FUN FACT

During a total solar eclipse, the longest the Moon can cover the whole Sun is just 7 minutes and 29 seconds.

Lunar eclipses

Full Moon is the only time you can see a lunar eclipse. That's because the Sun and Moon have to be on opposite sides of Earth for the Moon to go through Earth's shadow. But an eclipse doesn't happen every Full Moon because the Moon isn't exactly lined up with Earth.

SES

OUR SUN IS A SUPER STAR!
LOWELL OBSERVATORY
FLAGSTAFF AZ

GIRL: MICHAEL E. BAKICH

IMPORTANT SAFETY TIP

The ONLY time it's safe to look at the Sun is during the total phase of an eclipse. NEVER look at the Sun at any other time unless you have safe solar glasses. Sunlight can hurt your eyes and even blind you.

ECLIPSE SHADES
Astronomy

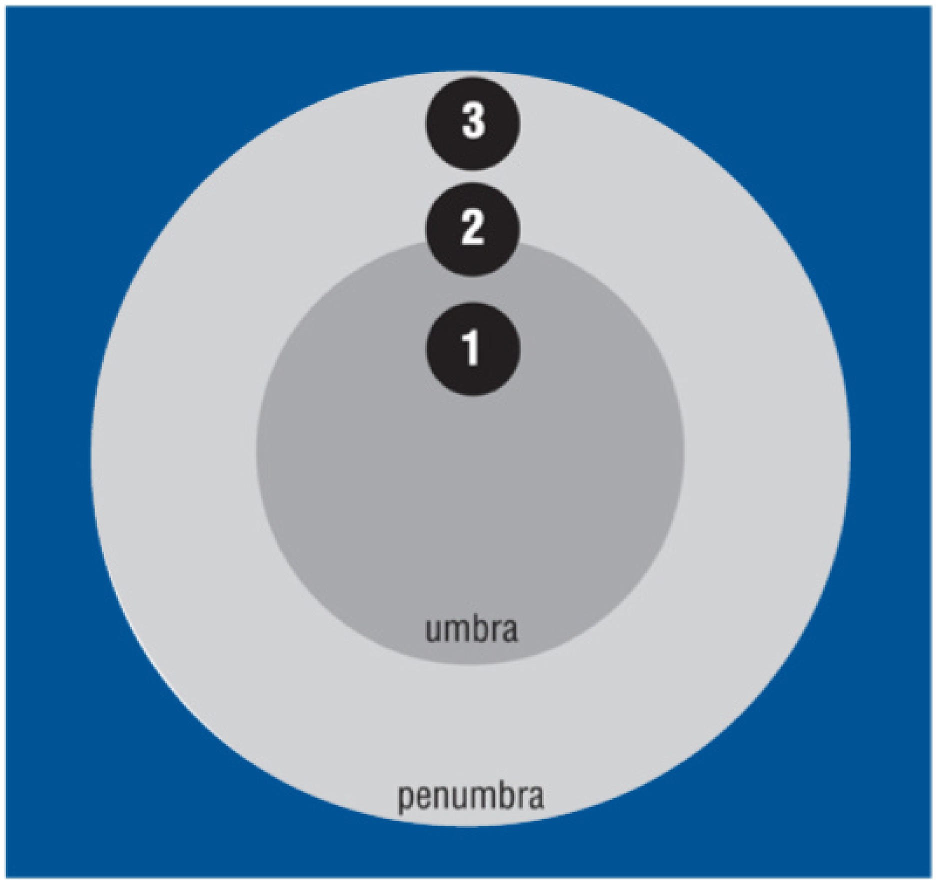
When one does happen, everyone on the night side of Earth can see it. So, in your life you will be able to see many more lunar eclipses than solar eclipses.

There are three types of lunar eclipses: total, partial, and penumbral. If Earth's umbra covers the whole Moon, that's a total lunar eclipse. The length of totality of a lunar eclipse can be as long as 1 hour and 40 minutes.

The Moon doesn't disappear during a total lunar eclipse because Earth's atmosphere bends some sunlight onto the Moon's surface. Total lunar eclipses can have a wide range of colors, from dim yellow-white to orange, copper, reddish-brown, and nearly black. The color mainly depends on how much dust and clouds are in our atmosphere at the time of the eclipse.

We'll see a partial lunar eclipse when Earth's umbra covers only part of the Moon. And a penumbral lunar eclipse happens when just Earth's penumbral shadow touches the Moon. Most people never even know that a penumbral eclipse is happening. It's easy to see one if about half the Moon is covered by the penumbra.

All three types of lunar eclipses are easy and safe to watch, because you're looking only at a shadow on the Moon. You won't need any equipment, although binoculars will give you a good view.



This shows what can happen when there's a lunar eclipse. The black circles are the Moon. The two big circles are the darker and lighter parts of Earth's shadow. If the Moon is at 1, the eclipse is total. If it's at 2, the eclipse is partial. If the Moon is at 3, the eclipse is penumbral. HOLLEY BAKICH

Solar eclipses

Solar eclipses can happen only at New Moon because that's when the Moon is between the Sun and Earth.

UPCOMING SOLAR ECLIPSES VISIBLE IN THE U.S.

DATE	TYPE	LENGTH OF TOTALITY
October 14, 2023	Annular	4½ to 5 minutes
April 8, 2024	Total	4 minutes and 27 seconds maximum
January 14, 2029	Partial	—
November 14, 2031	Partial	—
August 23, 2044	Total	1 minute and 44 seconds maximum

UPCOMING TOTAL LUNAR ECLIPSES VISIBLE IN THE U.S.

DATE	LENGTH OF TOTALITY
May 26, 2021	14½ minutes
May 16, 2022	1 hour and 25 minutes
November 8, 2022	1 hour and 25 minutes
March 14, 2025	1 hour and 5 minutes
March 3, 2026	58 minutes

They don't happen at every New Moon for the same reason we don't see lunar eclipses at every Full Moon.

When there's a solar eclipse, the Moon's shadow falls on Earth. And, like with lunar eclipses, there are three types of solar eclipses: total, partial, and annular. If the Moon completely covers the Sun's face, the eclipse is total. If the Moon covers just part of the Sun, the eclipse is partial. And there are times when the Moon's umbra doesn't quite reach Earth. That makes it an annular eclipse. (The name comes from *annulus*, the Latin word for "ring.")

Usually, not many people get to see total solar eclipses. The Moon's umbra isn't very wide when it touches Earth, so it doesn't cross over big cities often.

You'll see a total solar eclipse only if you're in a thin path along Earth's surface. The path is long, though. An average one stretches 9,300 miles (15,000 kilometers).

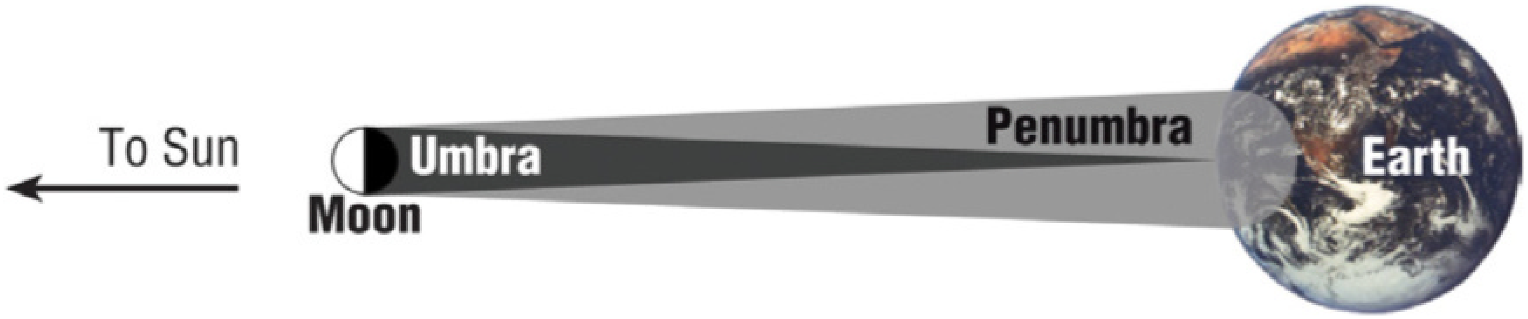
We can see partial solar eclipses over a much larger area. A partial eclipse can happen when the Moon's umbra misses Earth, or a total eclipse can look partial if you're not under the dark part of the Moon's shadow.

FUN FACT

The most recent total solar eclipse in the United States happened August 21, 2017.

The Moon does not disappear during a total eclipse. It does change colors, though.

ANTHONY AYIOMAMITIS



For solar eclipses, anyone on Earth under the Moon's umbra will see a total eclipse. Anyone under the penumbra will see a partial eclipse.

HOLLEY BAKICH

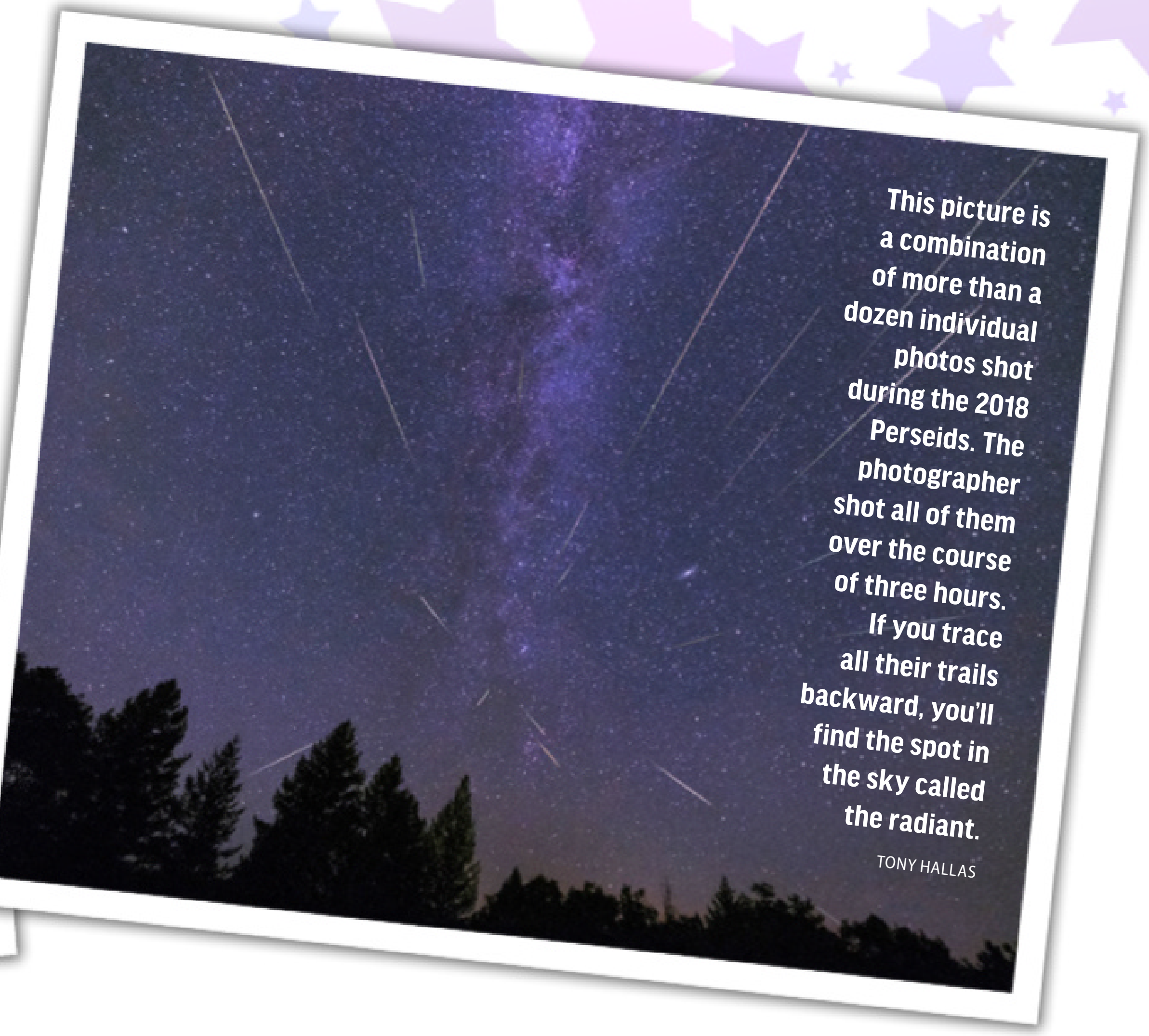
ALIEN (P. 72) AND ASTRONAUT (THIS PAGE): DANIELFELA/DREAMSTIME

Q: How do you throw a party in outer space?
A: You planet!

by Mike Reynolds

Chase a

This beautiful meteor streaked through the sky during the Perseid meteor shower in 2018. Like most bright meteors, it showed lots of color. DANIEL CHAMARATOS



This picture is a combination of more than a dozen individual photos shot during the 2018 Perseids. The photographer shot all of them over the course of three hours. If you trace all their trails backward, you'll find the spot in the sky called the radiant. TONY HALLAS

WHAT YOU'LL NEED!

- ☐ An adult to go with you
- ☐ The star chart on the next page
- ☐ A marker
- ☐ A dark place with a good view of the sky
- ☐ A lawn chair (One that reclines is best.)
- ☐ A dim flashlight, or one with a red filter on it
- ☐ Other things you might want to take are a blanket, a cold (or warm) drink, and insect repellent

Anti Mosquito
Aerosol
Insect Repellent
50% DEET
With plant extracts

HAVE YOU EVER BEEN OUTSIDE at night and seen something bright streak across the sky? These streaks are meteors — pieces of metal or rock falling through our atmosphere. They travel really fast, so friction with the air makes them burn, and they leave a streak of light behind as they fall.

From a dark place at any time, you can see about six meteors per hour. But during a meteor shower, you can see more. Showers happen when, at the same time each year, Earth passes through streams of tiny particles left by comets. Meteors in a shower all seem to start around the same spot in the sky. This spot is called the radiant, and a shower gets its name from the constellation the radiant is in. So, for example, meteors in August's Perseid meteor shower come from the constellation Perseus the Hero.

For a meteor shower, you don't need a telescope or binoculars. Your eyes work best because they show you the biggest chunk of the sky.

What to do

1 Decide when to observe the Perseid meteor shower, which peaks August 12 each year. You can read about other meteor showers in *Astronomy* magazine or online at Astronomy.com.

2019 Not a good year because the Moon will be bright.

2020 The Moon will rise around 1 A.M. So you can watch meteors until around 2 A.M.

2021 Great conditions! A thin crescent Moon will set a couple hours after sunset.

2022 Stay home. Full Moon happens the night the Perseids peak.

2023 Good conditions. A fat crescent Moon will rise around 3 A.M.

2 Head with an adult to the dark place you've picked out.

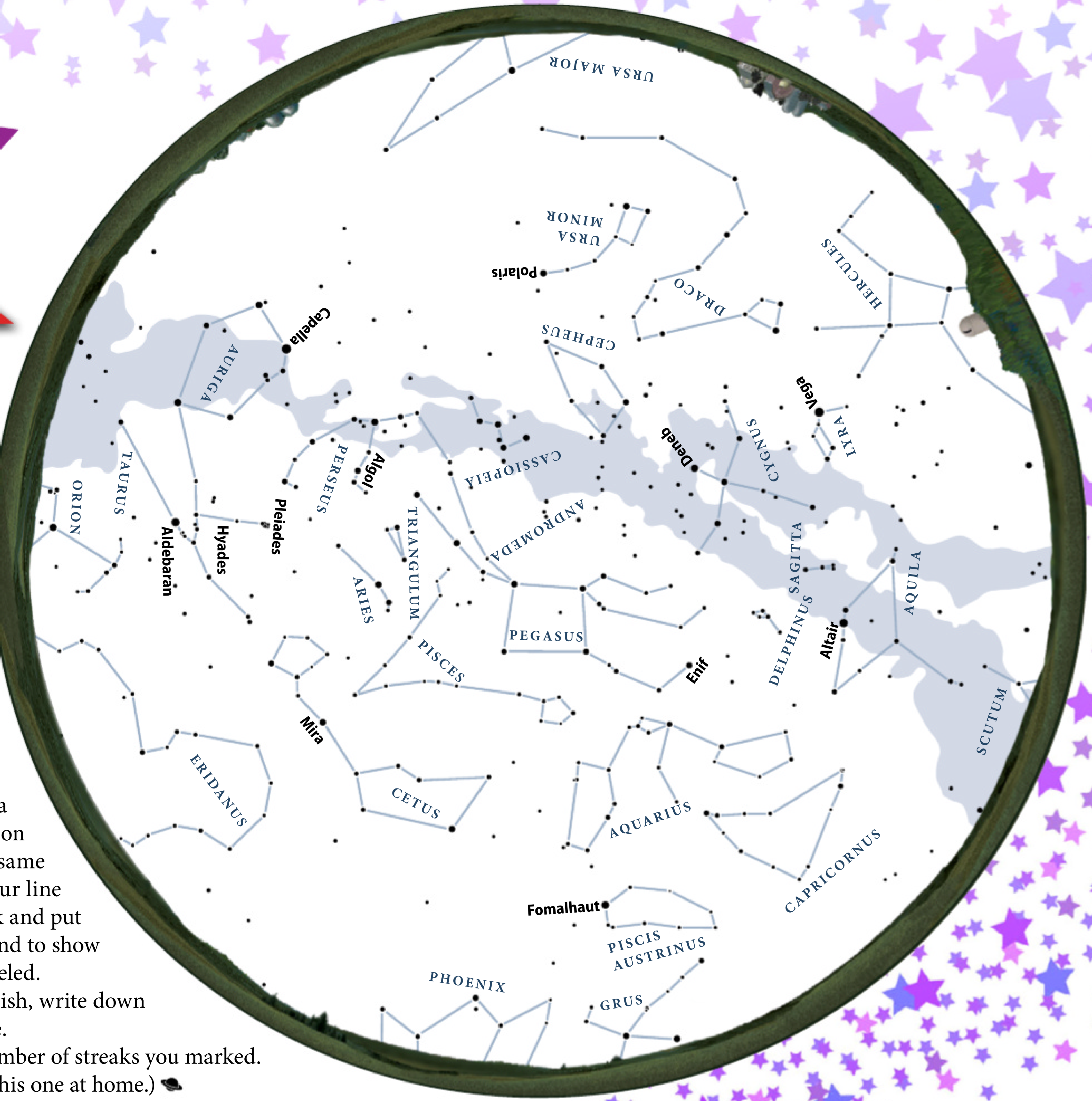
3 Put away your cellphone. Its light will make your eyes less sensitive.

4 Use the star chart on the next page.

5 Sit in your chair and face north. To do that, find the North Star. See p. 21 for help in doing that.

shooting star!

STAR CHART


URSA MAJOR
URSA MINOR
Polaris
DRACO
HERCULES
CEPHEUS
Capella
AURIGA
Vega
LYRA
Deneb
CYGNUS
CASSIOPEIA
Algol
PERSEUS
TAURUS
ORION
Aldebaran
Hyades
Pleiades
TRIANGULUM
ANDROMEDA
ARIES
SAGITTA
AQUILA
PEGASUS
PISCES
DELPHINUS
Altair
Enif
SCUTUM
Mira
ERIDANUS
CETUS
AQUARIUS
CAPRICORNUS
Fomalhaut
PISCIS AUSTRINUS
PHOENIX
GRUS

6 Match at least two constellations on the chart with real ones. After that, it should be easy to find other bright stars and constellations. For more help, use the star chart on this page.

7 Write down your starting time. Then watch. Every time you see a meteor, draw a line on the chart that's the same as its trail. Make your line as long as the streak and put an arrow tip at its end to show the direction it traveled.

8 When you finish, write down your end time.

9 Count the number of streaks you marked. (You can do this one at home.)

DECIMAL FUN!

Here's something extra you can do if you know decimals. You can figure out the average number of meteors you saw each hour, just like astronomers do. And you can do this whether or not you drew the paths of the meteors on the chart. Here's how:

a. Count the hours you watched. For example, if you looked at the sky from 12:40 A.M. until 3:15 A.M., that's 2 hours and 35 minutes. Thirty-five minutes is 35/60 of an hour, or 0.583 hour. So, you watched a total of 2.583 hours.

b. Divide the total number of meteors you saw by 2.583. If you saw 114 meteors, that would be 114 ÷ 2.583 = 44. So, your average meteor count was 44 meteors per hour. Congratulations!

STAR CHART: *ASTRONOMY*: ROEN KELLY. INSECT REPELLENT: ALEXLMX/DREAMSTIME. SHOOTING STARS: OLEKSANDR MALYSH/DREAMSTIME

Space word search

SEARCH FOR THE 50 ASTRONOMY WORDS in the column to the right. Take your time — words run up and down, sideways, diagonally, and backward. If you see a word that you don't know, check out the Glossary on p. 90. And if you need it, you'll find the solution on p. 98.

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N M A M A P Y V Z U I S T E P M O N O S A Y S I E
X O E R O K X L B J P E D O P R A B R X U I R T I
L X I R O O W Y W E M C L B I O S T H U X N F A Q
V H B T C R N A C O K A O O R E C J T A T Z E C G
D O E B C U U T C A R E N N R E N S H E N A J V S
U D M G N E R A L I J H M V N X K Q E I R T S U N
V H O G F U L Y S U Z Z A W J O Q A Y L U T N T W
X V T I M T V F Q L X T W J U P I T E R E G H N X
T A A R T K X M E R O H Y Y R L B D M B Y T Z F S
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Z O E M I W U U S N S M L E L O O I A A S R U G X
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M R M A R S T A R E T S U L C S I H N K L O B E W
G A W S V U T P C P A S U L M T T L B Z L R I P S
W A V E L E N G T H U R L I E A C R C F A E G T U
G C E O L S W M U N Z W T G T R A Q O E T T O U N
D T V L M O L E C U L E H H E G R J B N I S M N A
K E I E C N E I C S E J M T O R F N W P O A Y E R
R T J U U R E C N E N I M O R P E M V W N M B Q U
E Q S C C R R F B I M S R D G A R E N Q R H Y L K
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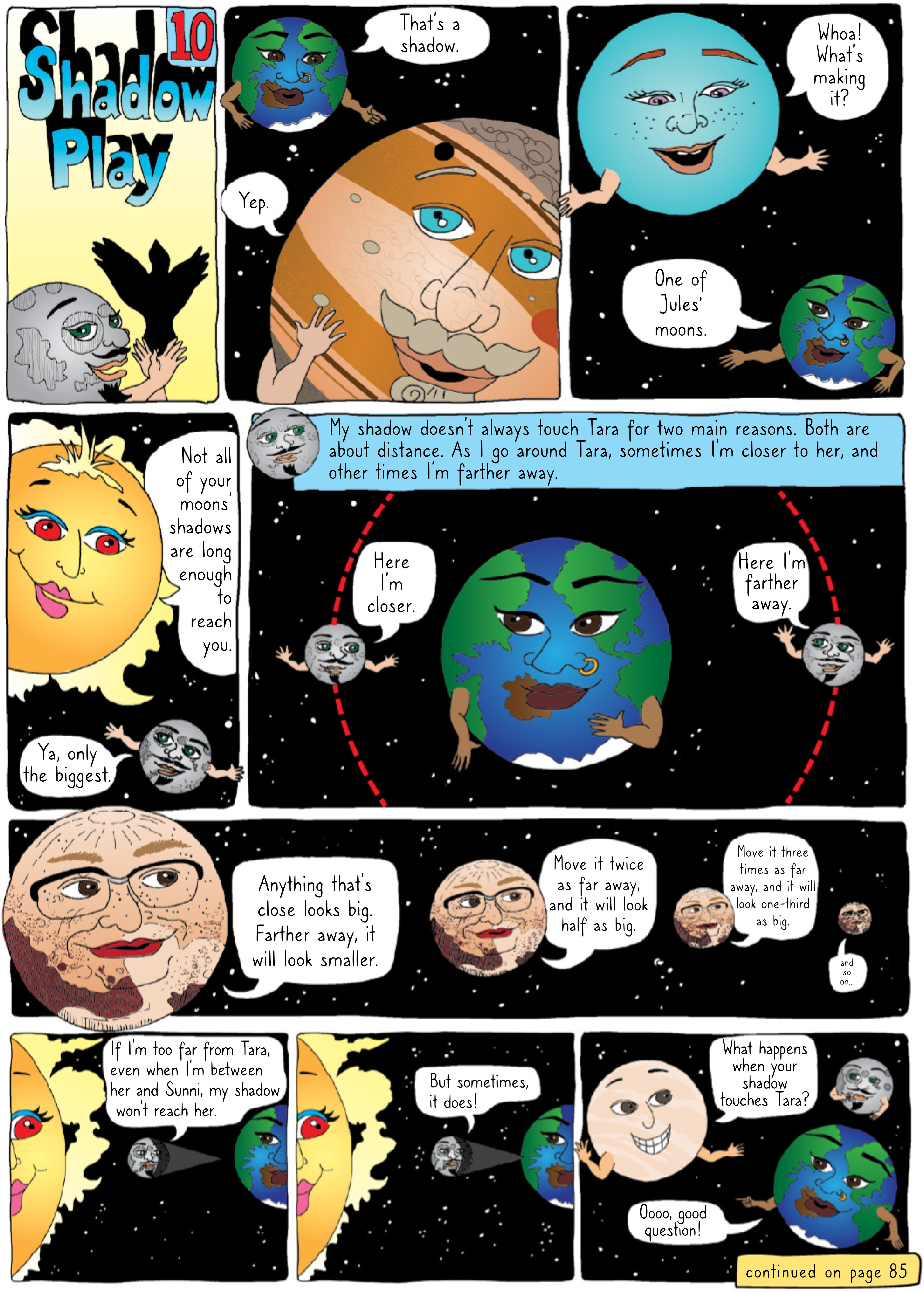
- ☐ Asteroid
- ☐ Astronomy
- ☐ Atom
- ☐ Aurora
- ☐ Axis
- ☐ Cluster
- ☐ Comet
- ☐ Constellation
- ☐ Crater
- ☐ Crescent
- ☐ Cygnus
- ☐ Draco
- ☐ Earth
- ☐ Eclipse
- ☐ Exoplanet
- ☐ Galaxy
- ☐ Gibbous
- ☐ Gravity
- ☐ Jupiter
- ☐ Light
- ☐ Mars
- ☐ Matter
- ☐ Mercury
- ☐ Meteor
- ☐ Molecule
- ☐ Moon
- ☐ Nebula
- ☐ Neptune
- ☐ Observatory
- ☐ Orion
- ☐ Planet
- ☐ Pluto
- ☐ Polaris
- ☐ Prominence
- ☐ Reflection
- ☐ Refraction
- ☐ Revolution
- ☐ Rotation
- ☐ Satellite
- ☐ Saturn
- ☐ Science
- ☐ Scorpius
- ☐ Spectrum
- ☐ Star
- ☐ Sun
- ☐ Supernova
- ☐ Telescope
- ☐ Uranus
- ☐ Venus
- ☐ Wavelength

NATALIIA2910/DREAMSTIME


10
Shadow Play
That's a shadow.
Yep.
Whoa! What's making it?
One of Jules' moons.
Not all of your moons' shadows are long enough to reach you.
Ya, only the biggest.
My shadow doesn't always touch Tara for two main reasons. Both are about distance. As I go around Tara, sometimes I'm closer to her, and other times I'm farther away.
Here I'm closer.
Here I'm farther away.
Anything that's close looks big. Farther away, it will look smaller.
Move it twice as far away, and it will look half as big.
Move it three times as far away, and it will look one-third as big.
and so on...
If I'm too far from Tara, even when I'm between her and Sunni, my shadow won't reach her.
But sometimes, it does!
What happens when your shadow touches Tara?
Oooo, good question!

continued on page 85

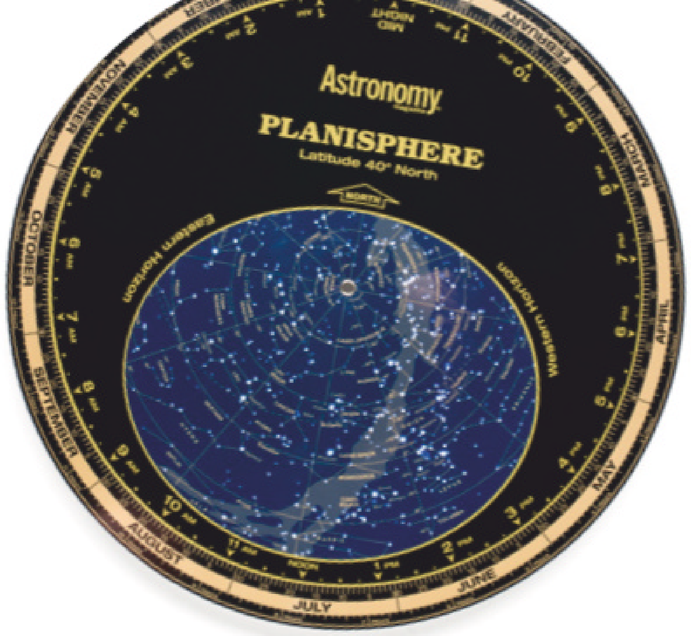
35 STEM PRODUCTS for fun learning!

by Phil Harrington

A NOTE FOR PARENTS AND TEACHERS: Can you recall the fascination you had as a child when you looked up at the stars in the night sky? I remember one special winter night when I was maybe 7 years old, sleigh riding in my backyard. The snow made it light enough to see the ground, but the stars blazed overhead. I looked up and saw three perfectly spaced, equally bright stars, and said to my mom, “I wonder if scientists know about them.” I had just discovered the Belt of Orion.

Children have a natural curiosity about the night sky. We see signs of that all around us, in books, television, movies, and other popular media. As adults, we should foster this interest, as my parents did with me, to cultivate a passing comment into a lifelong fascination.

Fortunately, there are many products available today to nurture a young person’s interest in the universe. Here is a quick look at 35 of the best, arranged alphabetically. As you’ll quickly see, there are plenty of ways to fuel that fascination with the sky. Whether it be a book, a puzzle, a model, or a telescope, the sky is not the limit. And we’ve made it simple, too. You’ll find all of these great products online at MyScienceShop.com.

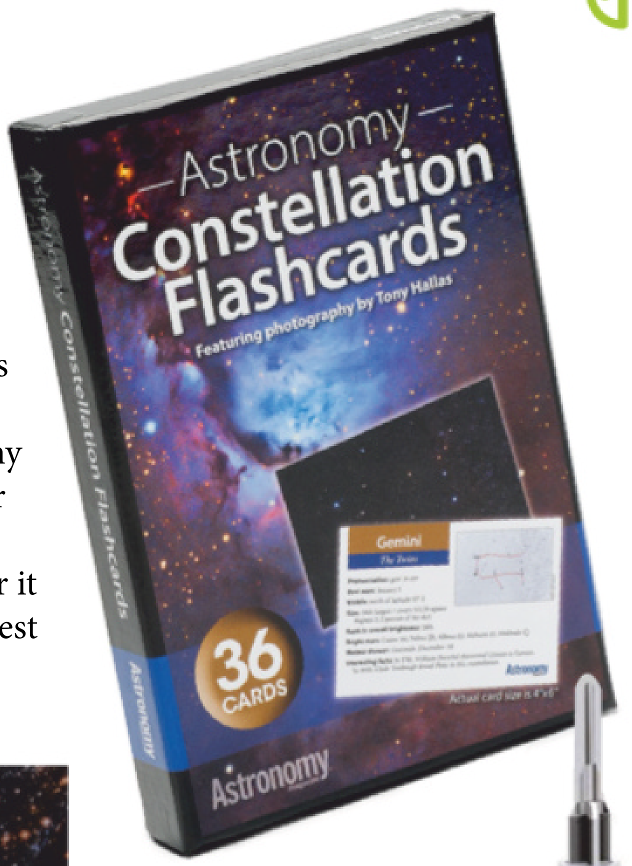


1 3D Comet 67P

Wouldn't it be great if a child could actually hold a comet in their hands? We can't offer that, but this accurate 3D model of Comet 67P/Churyumov–Gerasimenko's nucleus is the next best thing. When the European Space Agency's Rosetta mission went into orbit around the comet in 2014, astronomers were surprised to see images that showed the nucleus was made of two chunks connected by a bridge, or neck. It reminded some scientists of a rubber ducky. This to-scale replica is created from Rosetta's three-dimensional images. The model also includes a brochure detailing the comet's discovery and features.

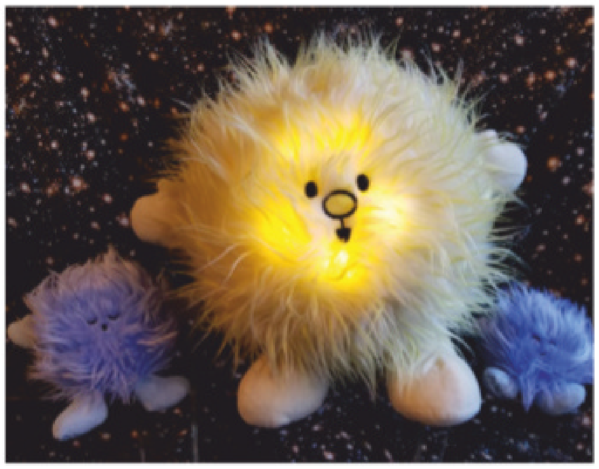
2 Constellation Flashcards

Help your young astronomer enjoy the beauty of the night sky while learning the prominent constellations with this set of 36 flashcards. One side of each card features a beautiful shot of the constellation taken by acclaimed astroimager Tony Hallas. The flip side includes proper pronunciation, times when the constellation is visible, where to look for it in the sky, information on its brightest stars, and other details.



3 Astronomy 40° North Planisphere

This star finder, or planisphere, makes it easy for everyone to find and identify which stars and constellations are visible at any time of night for any day of the year. By simply dialing in the date and time, you'll see which stars are above the horizon at that moment. The planisphere shows constellation names and outlines and more than 1,000 stars down to 5th magnitude. Many bright stars are labeled by name. On the back are instructions and the locations of the naked-eye planets for the next several years. Best for children 10 years and older.

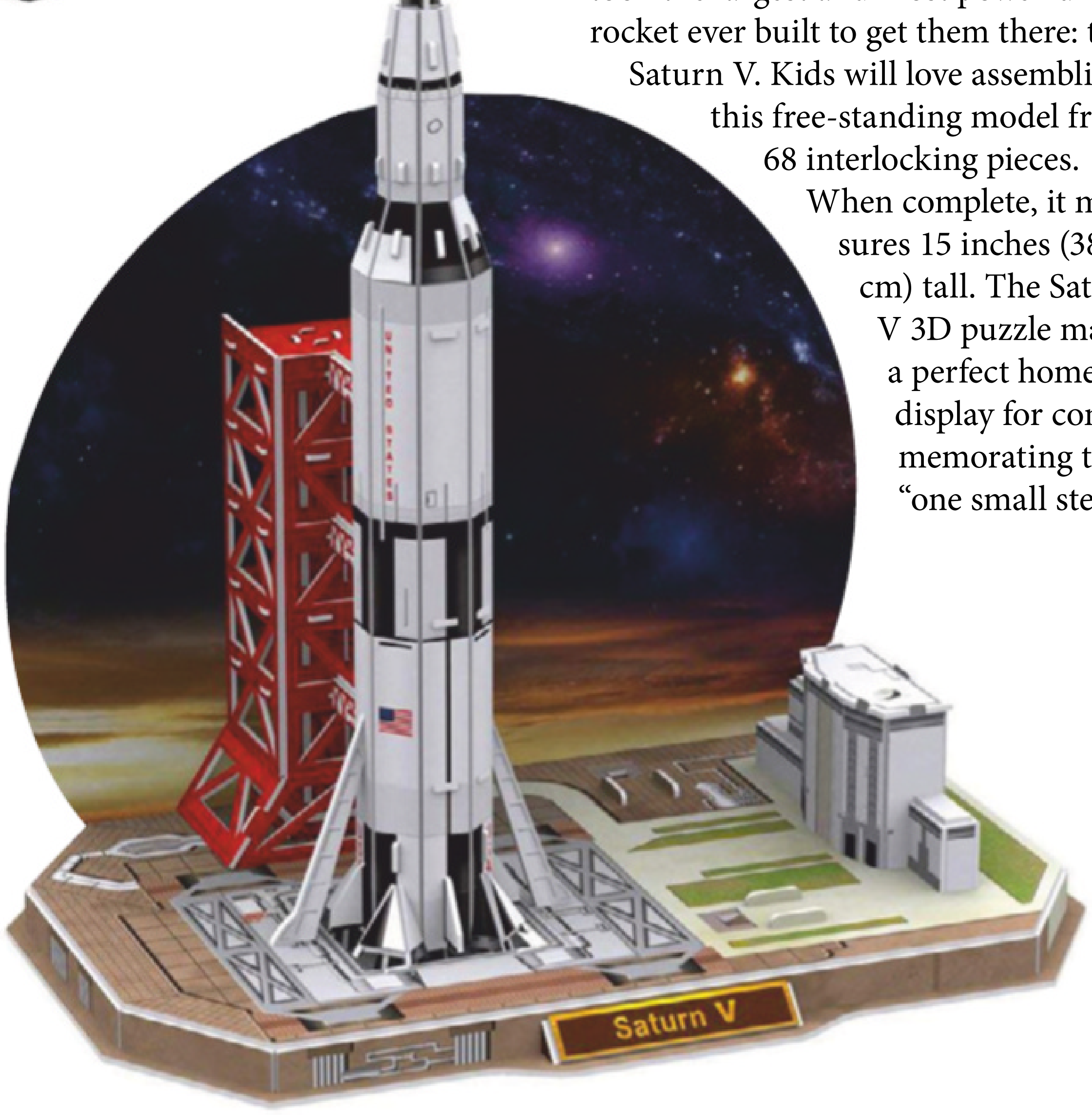


4 Celestial Buddies Plush Package – Sun, Earth, & Moon

Celestial Buddies is a series of stuffed toys that will become fast favorites. This collection of three, which are also sold separately, is a great way to show even the youngest astronomers how Earth orbits the Sun and that the Moon orbits Earth. They are also ideal for showing how eclipses work. The Sun is approximately 9 inches (23 centimeters) in diameter, while the Moon and Earth are each approximately 5 inches (13 cm) across. Other members of the Celestial Buddies series include all major planets, dwarf planet Pluto and its moon Charon, Comet Polaris, and a black hole.

5 3D Puzzle Saturn V Rocket

July 20 is the anniversary of the Apollo 11 astronauts' landing on the Moon. It took the largest and most powerful U.S. rocket ever built to get them there: the Saturn V. Kids will love assembling this free-standing model from 68 interlocking pieces. When complete, it measures 15 inches (38 cm) tall. The Saturn V 3D puzzle makes a perfect home display for commemorating that "one small step."



OPPOSITE PAGE BACKGROUND: FENIX84/DREAMSTIME

WAY TO GLOW!
HANG ALL 8 PLANETS (plus Pluto) FROM YOUR CEILING
GLOW IN THE DARK
3-D SOLAR SYSTEM™
240 PIECES
WARNING:

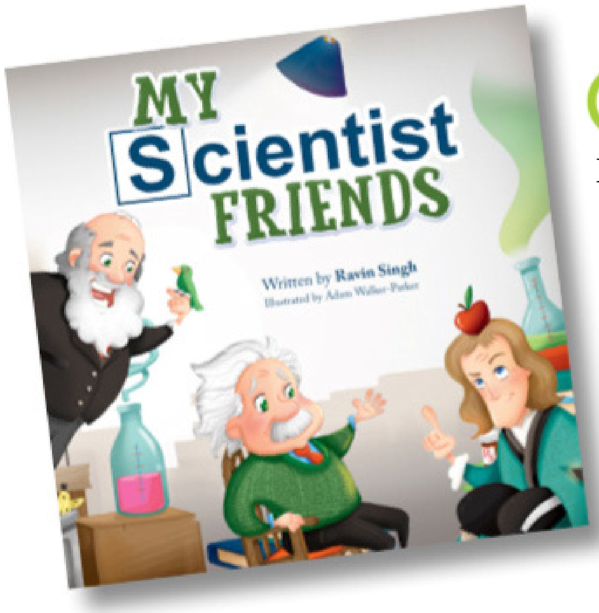
6 3-D Solar System

Bring the solar system into your home with this fun kit that's perfect for children 4 years and older. The set comes with planets that glow in the dark, as well as peel-and-stick stars, comets, and asteroids. The planets can be attached to a room ceiling with the provided string, while the adhesive-backed stars, comets, and asteroids can stick on the ceiling and walls. Turn on the lights to charge them, then turn off the lights and they glow in the dark. Young children especially love the effect.

Astronomy
DEEP SPACE MYSTERIES
2020
CALENDAR

7 2020 Deep Space Mysteries Calendar

The night sky is full of captivating sights throughout the year. To find out the date of the next meteor shower, eclipse, or other celestial event, turn to the 2020 Deep Space Mysteries wall calendar. Watching and enjoying these events is a wonderful experience that the whole family can share. Complete with colorful images, the calendar is a great addition to any room. And a new one comes out every year.



8 *My Scientist Friends*

In this brightly illustrated book, Ravin Singh captivates young minds with the wonderful world of science and some of the key scientists who changed our world. Mixing prose and poetry, the book introduces readers to Albert Einstein, Marie Curie, Galileo Galilei, Isaac Newton, and others. The engaging rhymes describe scientific concepts accurately, while making it fun for children to learn.

9 Pluto Globe

Kids young and old love Pluto. Until just a few years ago, it was nothing more than a tiny dot. All that changed in 2015, when NASA's New Horizons spacecraft flew past to return amazing images of that distant world. Working with members of the New Horizons team, *Astronomy* magazine created this first-ever globe of Pluto. Measuring 12 inches (30.5 cm) across, this plastic globe shows a large percentage of Pluto in high resolution. More than 65 regions and features are identified and labeled. The globe comes with a display stand that is perfect for home or classroom. Information detailing the historic New Horizons mission is included.

TOMBAUGH REGIO

10 Lunar Regular Model

With this 3D-printed and hand-painted replica of our planet's only natural satellite, kids can explore the Moon in the palms of their hands. Then, after installing the free companion AstroReality app (for iOS and Android) and using its augmented reality function, you can transport them into virtual lunar orbit to explore craters and other surface features, as well as sites of historic lunar missions. The Lunar Regular Model measures 3.1 inches (80 millimeters) in diameter, or a scale of 1:43,453,500.

ASTRO
SERIES 1
OWL 3-D
Stereo Cards

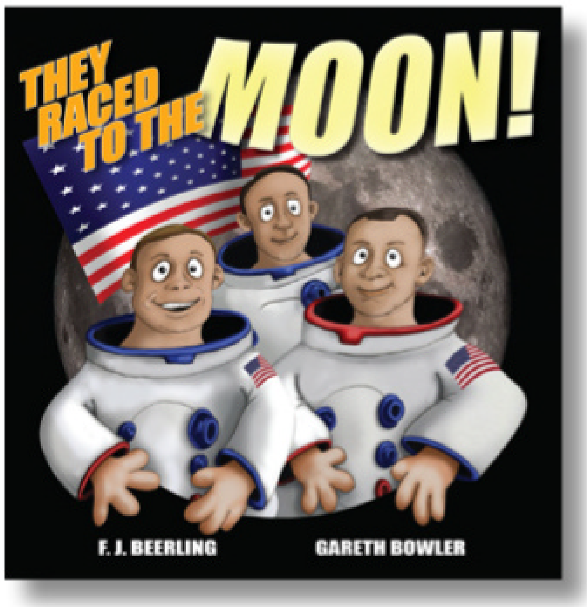
11 OWL 3-D Stereo Cards: Astro Series 1

The London Stereoscopic Company, manufacturer of the OWL Viewer, offers a wide selection of 3D cards to enjoy. This pack features 12 images selected by astrophysicist (and guitarist in the rock band Queen) Brian May, including our Sun in ultraviolet light, Buzz Aldrin standing on the Moon, mighty Jupiter, the ringed planet Saturn, and a total solar eclipse. The 3D effect pulls people into the scene. Each card includes information explaining the picture.

12 OWL 3-D Stereo Cards: Astro Series 2

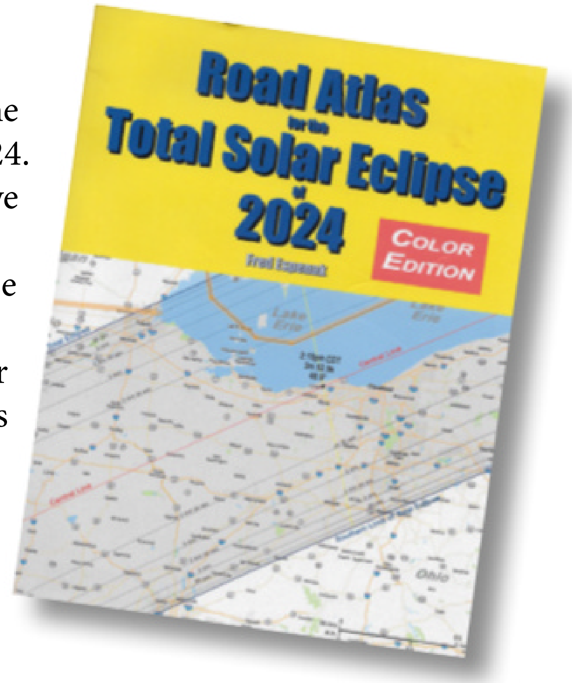
In this second series of 3D cards, Brian May has assembled magnificent images of the constellation Orion, a lunar eclipse, Comet Wild, a view from the martian surface, and more. As in the first set, each card includes information explaining the view. An adhesive-free box for archival storage is included with each set.

ASTRO
SERIES 2
OWL 3-D
Stereo Cards



13 *Road Atlas for the Total Solar Eclipse of 2024*

Road trip! The next total solar eclipse visible in the United States will take place Monday, April 8, 2024. For those of us who are already planning where we will be, eclipse guru Fred Espenak has created an indispensable road atlas that plots the exact eclipse path, from the Rio Grande to northern Maine, as well as portions of southeastern Canada. Whether you will be viewing from where the shadow enters the U.S. near Del Rio, Texas, or anywhere along the path as it heads into Canada from Holton, Maine, it's never too early to start planning your adventure to the next great American eclipse.



14 *They Raced to the Moon*

Author F.J. Beerling and illustrator Gareth Bowler have collaborated on more than a dozen highly acclaimed children's books covering a wide range of topics. In *They Raced to the Moon*, the pair teams up to trace the fascinating history of the United States' journey to the lunar surface. That culminated with the successful landing of Apollo 11 in 1969, but the project started many years before that. This historically and scientifically accurate account introduces young readers to the amazing engineering achievements, the international politics behind the space race, and the stories behind the people who went on to achieve one of humankind's greatest triumphs.

15 Meteorite Exploration Kit

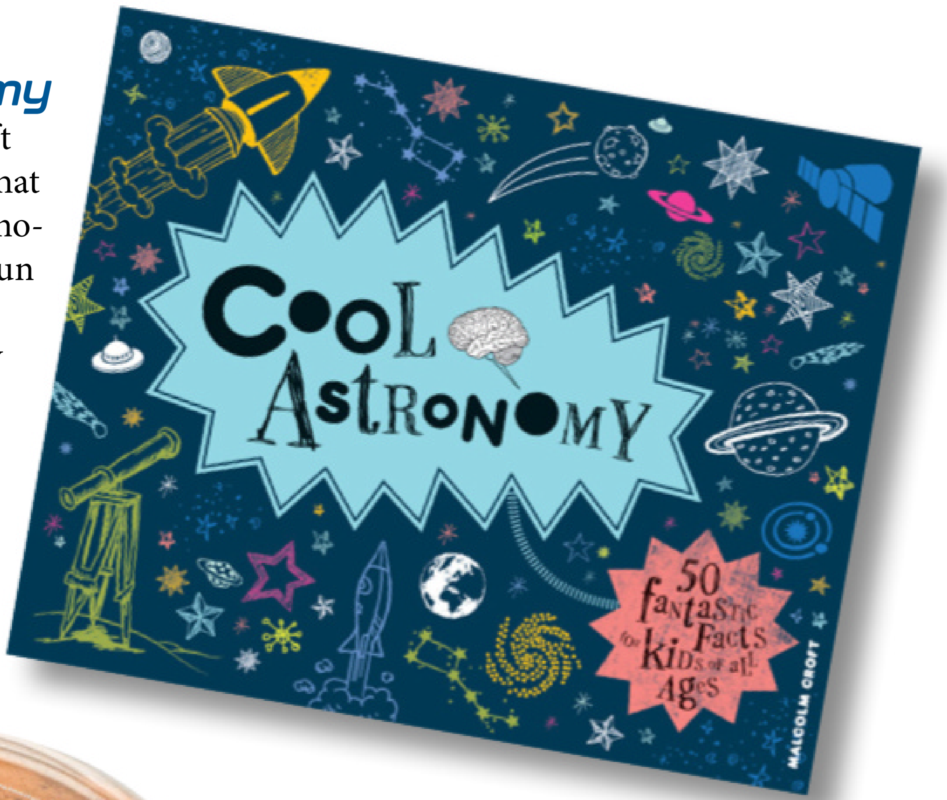
This kit is a great introduction for the entire family to the amazing world of meteorites. Developed by *Astronomy* contributing editor and meteorite expert Mike Reynolds, the kit comes with six authentic meteorite samples gathered from around the world, as well as three imposters (or "meteorwrongs"). Also included are a loop magnifier, magnet, and an identification card with facts about each sample. Everything is kept in the compartmentalized storage container.

METEORITE EXPLORATION KIT
Meteorites, Tektite, Impactite, and Meteorwrongs
Astronomy
Out of This World

NASA
SPACE ADVENTURE SERIES
Astronaut Doll
DARON

16 Cool Astronomy

Author Malcolm Croft has created an engaging book that is sure to captivate young astronomers. Inside are 50 illustrated fun facts and ways to advance and improve the reader's astronomy skills. You'll learn how to make a balloon rocket, how to map the stars from your backyard, and why the universe is like a loaf of bread.



17 Astronaut Doll

Standing 11.5 inches (29 cm) tall, this astronaut doll is perfect for high-flying play. Available with blond or brunette hair, the doll comes complete with an authentic shuttle uniform with NASA logo, and a rolling suitcase that opens and closes. The doll is a standard size, which means she can change into "civvies" when off duty.

18 Mars Globe

Elementary school children are quite familiar with globes of Earth. But what about other planets, like Mars? This beautiful 12-inch (30.5 cm) globe of the Red Planet is the most detailed one ever mass produced. Kids can imagine they are flying high over the planet's surface, as they look at martian craters, basins, valleys, and mission landing sites dotting the surface. The globe includes a clear acrylic display base for when they want to return to Earth. What a perfect addition to any classroom!

2278 Martian Minerals & Rocks Simulation Kit

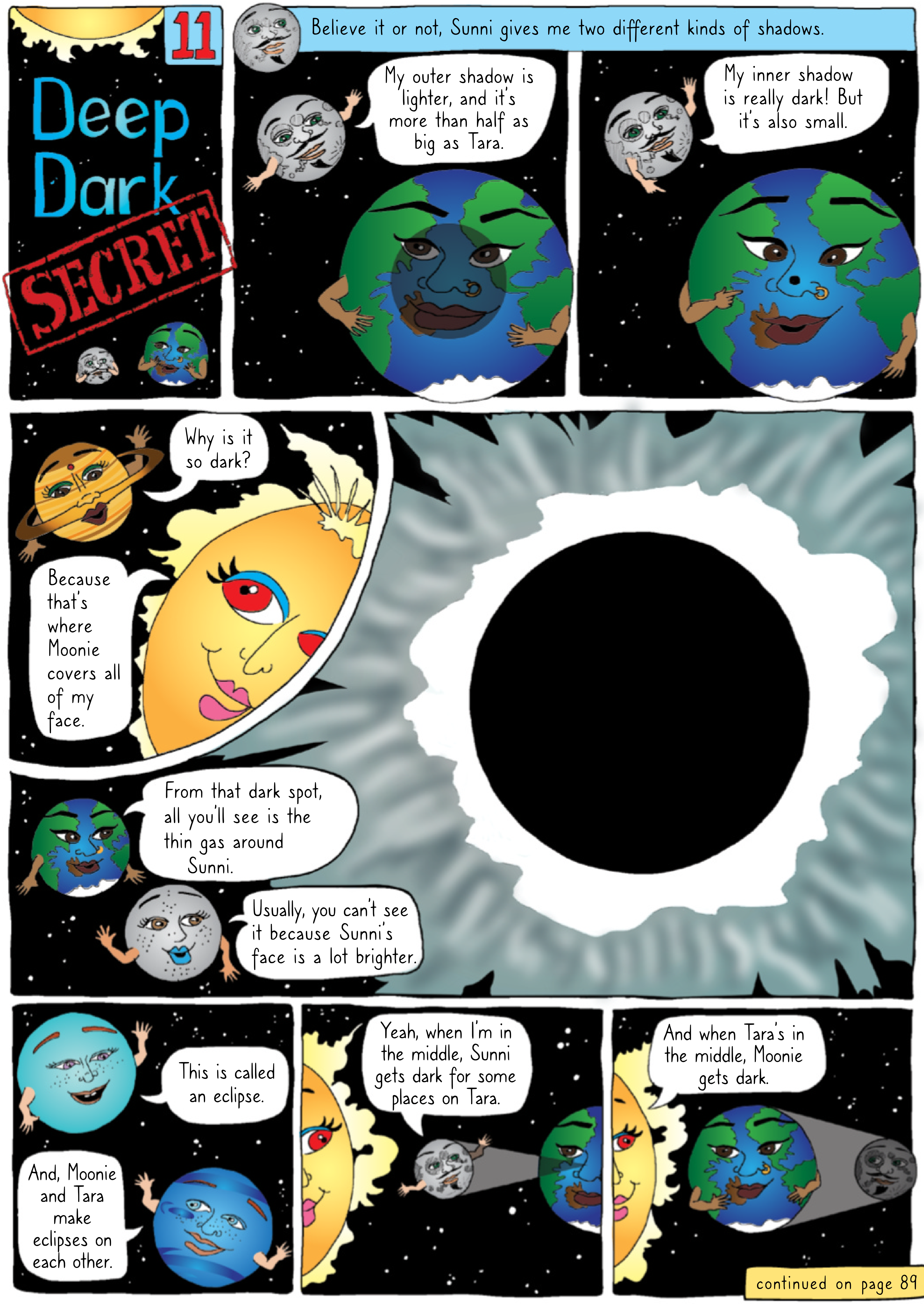
19 Mars Rock Kit

Although none of the robotic missions to Mars has returned any samples, we have a good idea what martian rocks are like, thanks to discoveries made from ongoing surface missions. Kids will be amazed with this collection of six samples of earthly rocks handpicked for their similarity to those found on Mars, including arenite, sulfur, and hematite. Characteristics of each sample are described in a booklet that comes with the kit. Everything stores safely in the included compartmentalized case.

20 Moon Rock Kit

One of the main goals of the Apollo missions to the Moon was to gather and return samples of lunar rocks and soil. While those are national treasures and never for sale, this collection of six examples found on Earth are geologically similar to those returned from the Moon. The kit includes a compartmentalized storage box, a guide with a detailed description of each sample, and classroom lessons on the formation of the Moon and its evolution.

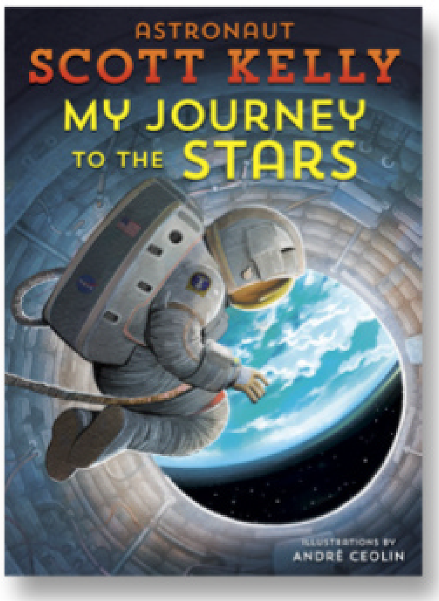
2275 Lunar Minerals & Rocks Simulation Kit


11
Deep Dark SECRET
Believe it or not, Sunni gives me two different kinds of shadows.
My outer shadow is lighter, and it's more than half as big as Tara.
My inner shadow is really dark! But it's also small.
Why is it so dark?
Because that's where Moonie covers all of my face.
From that dark spot, all you'll see is the thin gas around Sunni.
Usually, you can't see it because Sunni's face is a lot brighter.
This is called an eclipse.
And, Moonie and Tara make eclipses on each other.
Yeah, when I'm in the middle, Sunni gets dark for some places on Tara.
And when Tara's in the middle, Moonie gets dark.

continued on page 89

21 *My Journey to the Stars*

Written by astronaut Scott Kelly and illustrated by André Ceolin, this rousing book takes young readers through Kelly's journey through life on his way to becoming the first astronaut to spend a year in space. He recounts how he struggled academically in school and often got into trouble with his twin brother, Mark. This story of an ordinary boy who grew up to do extraordinary things will inspire the next generation of would-be astronauts as well as anyone who has ever tried to defy the odds.

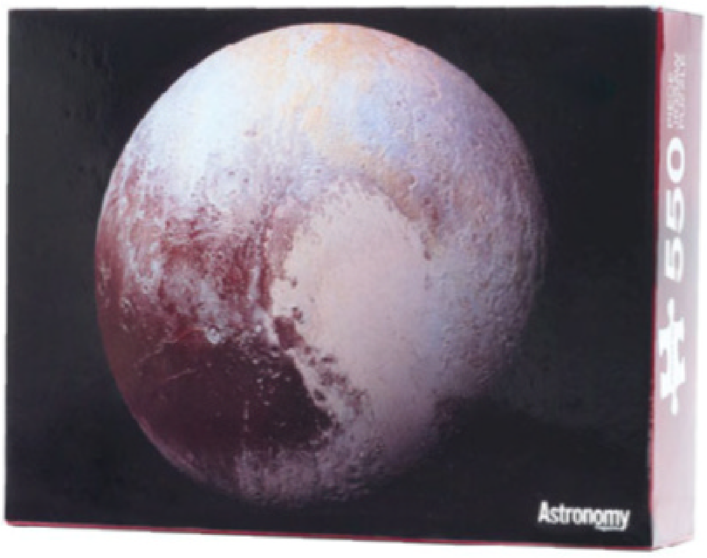


22 Celestial Buddies Plush – Black Hole

There's no better place to keep your Celestial Buddies than in the Celestial Buddies Black Hole. A real black hole's gravity is so great that nothing can escape. But here, by loosening the drawstring, all come out to play. The Celestial Buddies Black Hole measures 18 inches (46 cm) long and 16½ inches (42 cm) wide, large enough to hold all 12 other Buddies in the collection.

23 Solar System Bracelet

What child wouldn't want to take the solar system with them wherever they went? There's no better way than to wear it on your wrist. The Solar System Bracelet is a wraparound beaded bracelet that shows the Sun and all eight major planets in order on a springy spiral coil. Each bauble is shaded and sized to match its body's characteristics, with the Sun being the largest, Mars distinctly red, Jupiter banded in yellow and white, and Uranus and Neptune beautiful turquoise and blue. Saturn even shows off its classic ring system.



24 *Turn Left at Orion*

Since the first edition was published in 1989, *Turn Left at Orion* has become one of the most popular books for backyard stargazers of all ages. Written by Guy Consolmagno and Dan M. Davis, *Turn Left at Orion* provides all the information needed to find and observe a wide variety of celestial objects. After an introductory chapter discussing telescopes, the book embarks on journeys to the Moon and planets. Maps and finder charts throughout help readers locate the featured targets. Appendices give technical details of all objects discussed. Recommended for readers ages 10 and older.

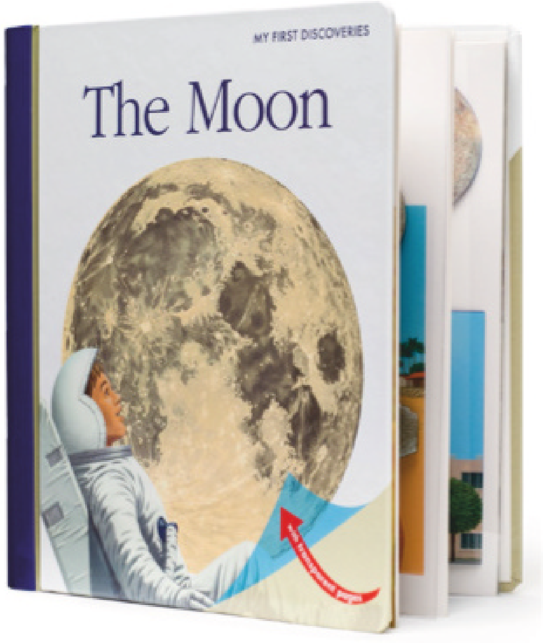
TURN LEFT AT ORION
HUNDREDS OF NIGHT SKY OBJECTS TO SEE IN A HOME TELESCOPE – AND HOW TO FIND THEM
Guy Consolmagno and Dan M. Davis

25 Pluto Jigsaw Puzzle

This puzzle makes a perfect rainy day or cloudy night activity for adults and children alike. Use the 550 pieces to assemble one of the most intricately detailed images ever taken of Pluto, captured by NASA's New Horizons Spacecraft as it flew by in 2015. The exquisite image measures 18 by 24 inches (46 by 61 cm) when assembled, perfect for framing and displaying.

26 The Moon

One of the first words my grandchildren learned was "Moon." They were fascinated by it from an early age, watching as it seemingly floated across the sky. This book will carry that childhood fascination to the next level using a series of captivating illustrations and diagrams combined with transparent overlays. Readers learn about some of the early attempts to reach the Moon as well as the first Moon landing, what causes the phases of the Moon, and how to view both lunar and solar eclipses. The book also looks at the satellites of other planets and even includes plans for building a Moon base. The durable wire binding is designed so the book lays flat.



OWL VIRTUAL REALITY KIT
USE ANY SMARTPHONE
INSTANT 3-D
LOOK !
Try me !
VR
OWL
KIT

27 OWL Stereoscopic Viewer

Designed by Brian May, the OWL Stereoscopic Viewer is perfect for examining 3D images found in a book, on stereo cards (see numbers 11 and 12 in this list), and even on tablets. The folding viewer is only ¼-inch (6 mm) thick when stowed, yet it assembles into a rigid precision instrument in just seconds. It comes packaged with complete instructions in a beautifully designed card wallet.

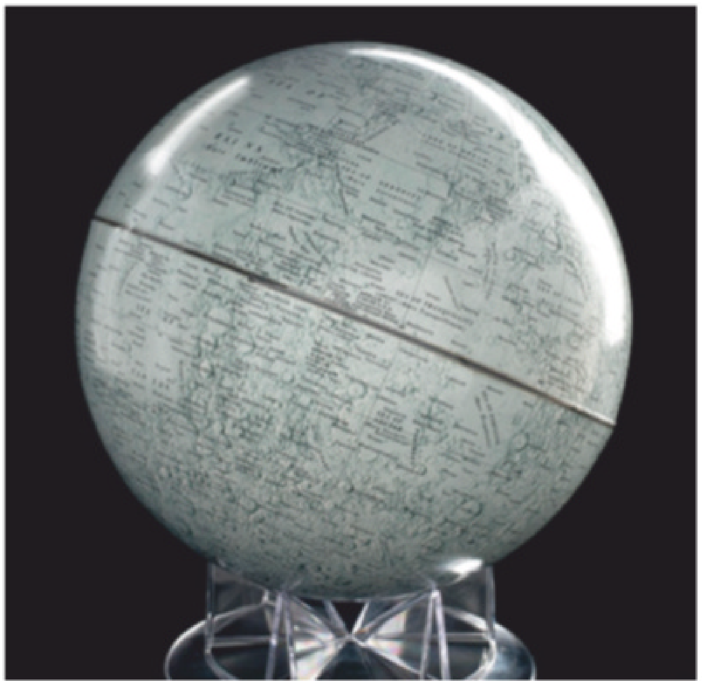
28 TK1 Telescope & Astronomy Kit

Many of us got our start as stargazers with a 2.4-inch telescope. The TK1 Telescope & Astronomy Kit harks back to those times and is perfect for engaging today's young astronomers in the same way. Two standard 1¼" eyepieces come with the scope. When the 20mm eyepiece is inserted into the focuser, views are magnified 35x, while the 10mm eyepiece doubles that to 70x. The scope also comes with a 90° star diagonal to make viewing comfortable, as well as a 5x24 finder scope for aiming. The alt-azimuth mount and extendable aluminum tripod holds the scope steadily. And you'll discover what's out there to look at in the 32-page book included with each TK1.

TK1 TELESCOPE & ASTRONOMY KIT
REFRACTOR 60/700
THAMES & KOSMOS
12+

29 Moon Globe

Bring the Moon down to Earth with this 12-inch (30.5 cm) globe that shows the entire lunar surface — both near and far sides — in stunning detail. Many of the Moon's major surface features, including the most prominent craters, mountains, and valleys, are clearly labeled. You'll even be able to pinpoint where the first manned lunar mission, Apollo 11, touched down. This globe is a great way to commemorate that historic event that took place way back in 1969.



SMARTLAB
8+
FACT-PACKED POSTER INSIDE!
SOLAR SYSTEM ADVENTURE
SOLAR SYSTEM MODEL WITH LIGHT-UP SUN!
BUILD A MARS ROVER!

30 Solar System Adventure Kit

This build-it-yourself kit will bring the solar system into your home or classroom, making it easy to see where our world lies with respect to the Sun and the other seven major planets. Each planet and the Sun snaps together easily. All are held securely on a base that lets children move the planets in their orbits. The Sun even shines after you insert two AA batteries. It's a great way to get a three-dimensional view of our celestial family. The kit also comes with a paper-and-plastic replica of NASA's Mars Curiosity rover that can easily be punched out and assembled. Finally, there's a fact-filled poster telling of each planet's unique features.

31 Water Rocket

If you have a recycled plastic 2-liter soda bottle, water, and a bicycle pump, get ready to lift off. Assemble these items you supply with the fins and tailstock included in the kit, and you'll have a rocket that will fly as high as 30 feet (9.1 m) into the air on hydraulic pressure. Unlike some similar products, the Water Rocket does not require using vinegar or baking soda for propellent.

SCIENCE IN ACTION
WATER ROCKET
BUILD YOUR OWN ROCKET USING JUST A BOTTLE, WATER AND A PUMP. WATCH THE ROCKET SOAR AS HIGH AS 30 METRES INTO THE AIR AS YOU PUMP AIR INTO IT!
WARNING
4M

32 Solar System Marble Set

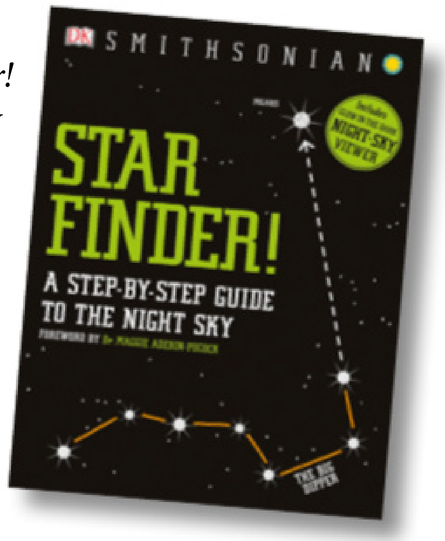
This set of 10 scaled glass marbles, representing the Sun, eight major planets, and dwarf planet Pluto, is sure to be a big hit with fledgling astronomers. It makes a great display for a bedroom dresser, desk, or classroom. Each marble comes with its own matching display ring that can be used with the included template to showcase the collection. And if you use a smartphone or tablet to scan the code on the back of the package, an interactive website full of fun space facts will launch. The Solar System Marble Set is the perfect combination of interplanetary education and entertainment that is out of this world.

33 Smithsonian Maker Lab Outdoors: 25 Super Cool Projects

Young scientists will love this book of 25 hands-on projects designed to teach them about the world. Examples include making a paper sundial, constructing a water rocket, plans for a latitude locator, making a rain gauge, and building a periscope. Each project includes detailed instructions and templates. Required supplies are commonly available from everyday sources.

DK SMITHSONIAN
MAKER LAB
OUTDOORS
Design a water rocket
25 SUPER COOL PROJECTS
Build · Invent · Create · Discover
JACK CHALLONER

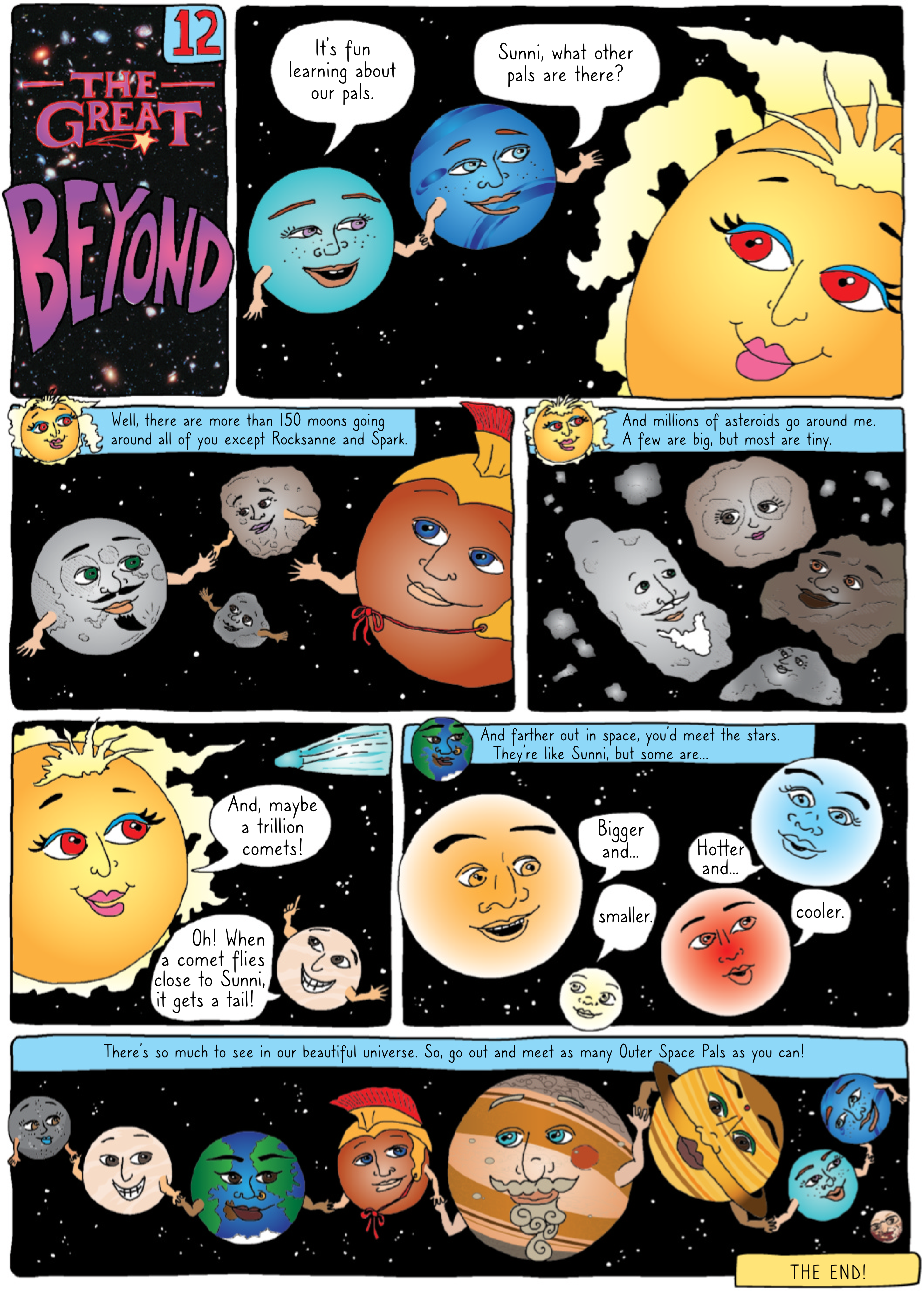
34 Star Finder! A Step-by-Step Guide to the Night Sky


DK SMITHSONIAN
STAR FINDER!
A STEP-BY-STEP GUIDE TO THE NIGHT SKY
Includes NIGHT-SKY VIEWER
THE BIG DIPPER

Dividing the sky into four routes, *Star Finder!* takes kids on a journey across each season's sky. In the spring, travel from the Big Dipper to Leo; in the summer, from Cygnus to Serpens; in autumn, from Cassiopeia to Aries; and finally in winter, from Orion to the Pleiades. Along each route, readers will learn the myths and legends behind each constellation, as well as how to spot some of the star clusters, nebulae, and galaxies hidden within. A separate chapter is devoted to viewing the Moon, planets, and meteor showers. Richly illustrated, this book comes complete with a glow-in-the-dark star finder.

35 Earth, Mars, and Moon to Scale Marble Kit

The late astronomer Carl Sagan once famously referred to our tiny planet as a "pale blue dot." This kit shows that, although Earth is small, it's the big kid on the block when compared to Mars and our Moon. All three are portrayed to scale in this collection, making it a great way to illustrate relative sizes. Earth is 1.4 inches (35.6 mm) in diameter, while Mars measures 1 inch (25 mm) and the Moon just 0.5 inch (13 mm) across. Three tabletop display stands are included, as are an information card and a storage pouch.


12
THE GREAT BEYOND
It's fun learning about our pals.
Sunni, what other pals are there?
Well, there are more than 150 moons going around all of you except Rocksanne and Spark.
And millions of asteroids go around me. A few are big, but most are tiny.
And, maybe a trillion comets!
Oh! When a comet flies close to Sunni, it gets a tail!
And farther out in space, you'd meet the stars. They're like Sunni, but some are...
Bigger and...
smaller.
Hotter and...
cooler.
There's so much to see in our beautiful universe. So, go out and meet as many Outer Space Pals as you can!
THE END!

Speak astronomy

by Michael E. Bakich

altitude How high anything is in the sky. Altitude runs from 0° (on the horizon) to 90° (straight up).

asteroid One of millions of small bodies that orbit the Sun and are not planets or comets. As of 2016, astronomers had found 709,706 asteroids, most of which lie in the asteroid belt.

asteroid belt An area between the orbits of Mars and Jupiter where most of the asteroids are found.

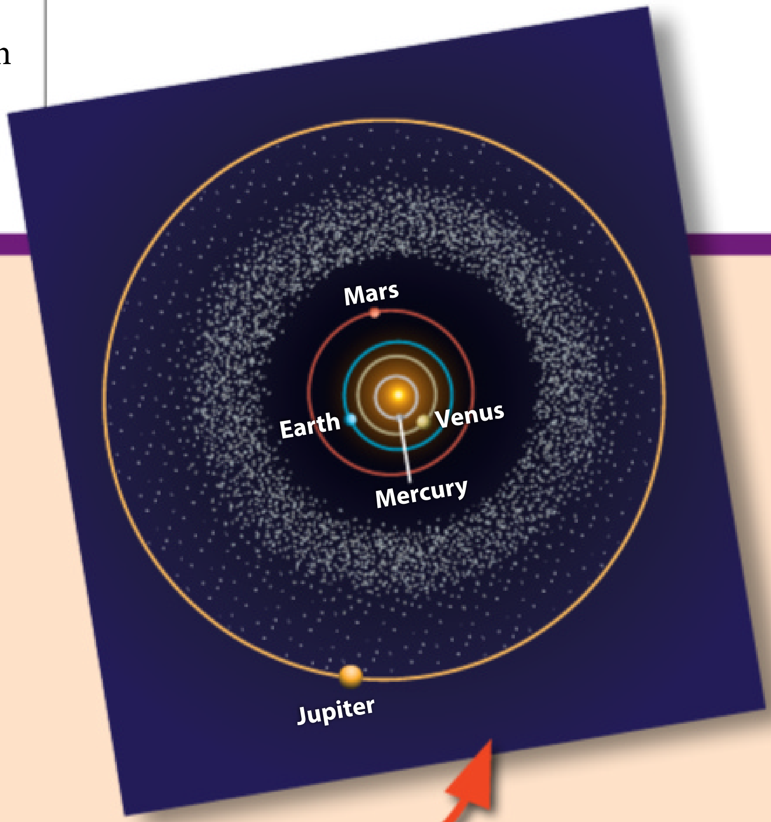
astronomical unit The average distance from Earth to the Sun (abbreviated AU). Astronomers have defined this distance as 92,955,807.3 miles (149,597,870.7 kilometers).

astronomy The study of the properties of celestial objects; the study of the universe as a whole.

comet One of many small solar system objects composed of frozen gases and dust that orbit the Sun.

asteroid

Vesta was the fourth asteroid discovered. NASA



asteroid belt

This area lies between Mars and Jupiter. *ASTRONOMY:* ROEN KELLY

comet

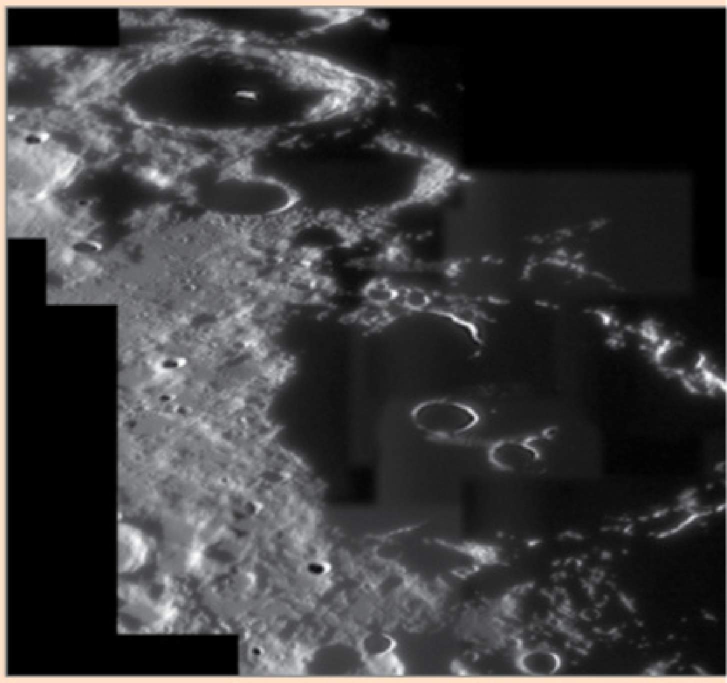
Bright comets are beautiful!

MARTIN MOLINE

ASTRONAUT: VALERIY KATREVICH/DREAMSTIME

constellation

Scorpius is a summer constellation. TONY HALLAS



constellation One of the 88 imaginary dot-to-dot patterns made of stars that cover the sky.

craters Round depressions on the surfaces of many objects in the solar system; most craters were created when a meteorite hit.

day One rotation (spin) of a planet on its axis. Earth's day lasts 24 hours.

eclipse When one celestial object's shadow falls on another object, the first object blocks out the Sun where the shadow falls. The eclipse can be total (the whole Sun blocked) or partial (part of the Sun blocked).

First Quarter The Moon's phase when we see half of it in the evening sky.

Full Moon A phase of the Moon when we see its whole face.

gibbous The Moon's phase anytime we see more than half but less than all of its face.

gravity The force that holds or pulls objects together.

inner planets Planets closer to the Sun than the asteroid belt: Mercury, Venus, Earth, and Mars.

Last Quarter The Moon's phase when we see half of its face in the morning sky.

lunar eclipse When the Moon passes through Earth's shadow; it's a total eclipse if the dark part of Earth's shadow covers all of the Moon's face.

meteor A streak of light in the sky caused by a tiny piece of rock or metal entering our atmosphere and burning up; sometimes called a "shooting star" or "falling star."

meteor shower What happens when Earth passes through a stream of particles; meteor showers happen every year on the same dates.

moon A natural body that orbits a planet.

New The Moon's phase when we can't see its face.

Full Moon

The Full Moon is always across the sky from the Sun. JOHN CHUMACK

First Quarter

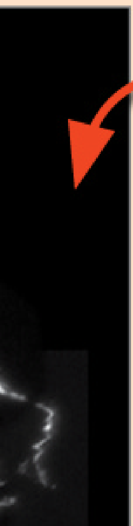
This phase of the Moon rises around noon. MIGUEL CLARO

gibbous

This word means "hump" — what the Moon can look like when it's not Full, but we see more than half its face. JAMIE COOPER

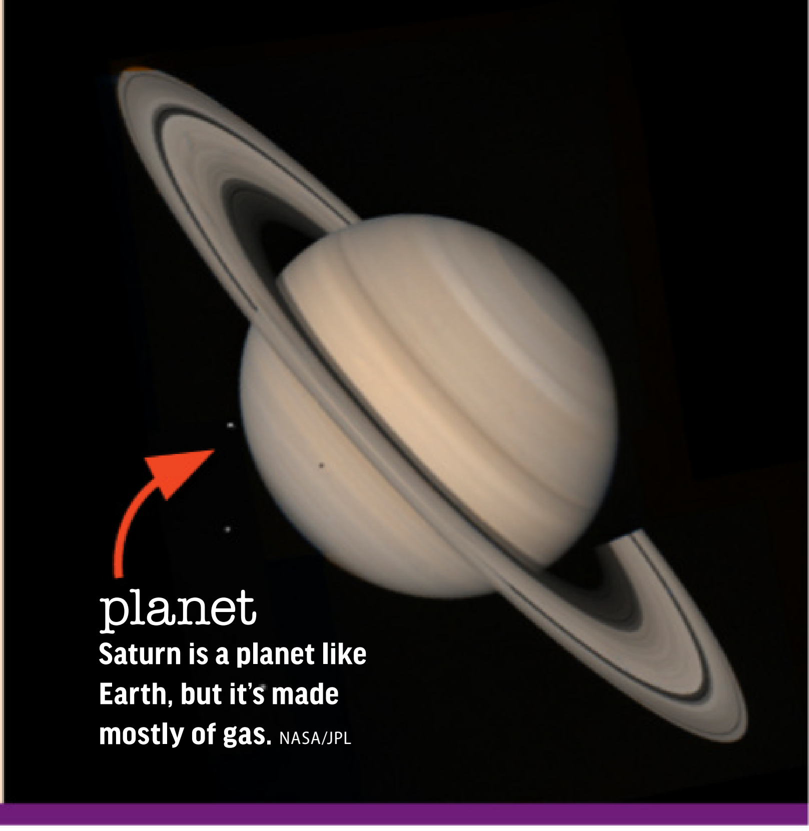
Last Quarter

This phase of the Moon rises around midnight. JAMIE COOPER



crater
Some craters on the Moon have craters inside them. DAMIAN PEACH

solar eclipse
During a total solar eclipse, we can see the Sun's outer atmosphere. MIKE REYNOLDS

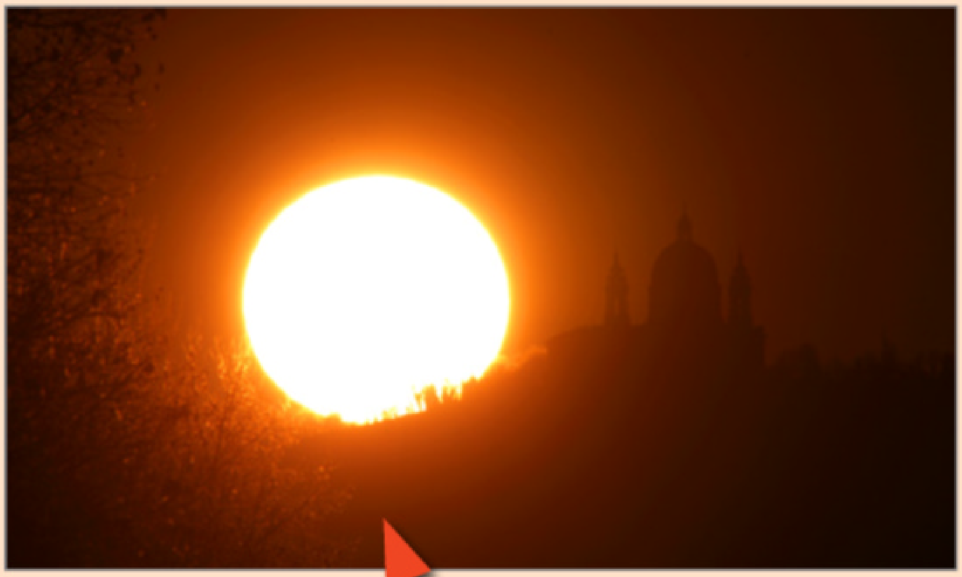


planet
Saturn is a planet like Earth, but it's made mostly of gas. NASA/JPL

lunar eclipse
If Earth's shadow touches the Moon, there is a lunar eclipse. ANTHONY AYIOMAMITIS

orbit	The path of one celestial object around another object.
outer planets	Planets farther from the Sun than the asteroid belt: Jupiter, Saturn, Uranus, and Neptune.
phase	The portion of the Moon or other solar system object that we can see at any time in its orbit.
planet	One of the eight main solar system objects that orbit the Sun and shine by reflecting its light.
reflecting telescope	This instrument uses a main mirror to collect light.
refracting telescope	This instrument uses a main lens to collect light.
rotation	The spinning motion of a planet or other celestial object around an axis.
satellite	A body that orbits a larger body.
solar eclipse	When the Moon covers all (total eclipse) or part (partial eclipse) of the Sun's face.
Sun	The star at the center of our solar system.
waning	The time when the lit part of the Moon is getting smaller.
waxing	The time when the lit part of the Moon is getting larger.
year	The time it takes Earth or any planet to make one complete orbit around the Sun.

meteor
Some are surprisingly bright. LARRY KUHN



Sun
Our star brings light and heat to Earth. STEFANO DE ROSA

OUTER SPACE Pals
Artwork by Holley Bakich

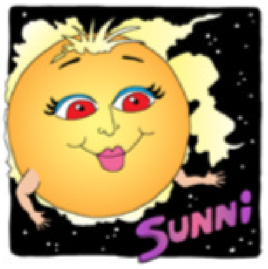
EXPLAINED

ASTRONOMY FOR KIDS contains 12 pages that feature *Outer Space Pals*. This comic is a lot of fun, but parents and teachers can help kids get even more out of it by discussing with them the scientific ideas involved. Here's a guide to concepts in *Outer Space Pals* with which you might not be familiar.

Opening page (p. 9)

Panel #1 (after *Outer Space Pals* title)

- A long time ago = 4.568 billion years. Planetary scientists think that's how long ago the solar system formed.
- All objects with mass (in other words, made of stuff) have gravity. The more mass, the more gravity. So, as things began to grow in size (mass), they had more gravity and were able to attract more stuff and grow larger.



- The tiniest particles in the early solar system didn't have much mass. If they weren't attracted to a larger mass, they are still the same particles today, spread throughout the space between worlds.
- Gravity caused uncounted collisions, especially early on and close to the Sun where most of the particles were. As particles stuck together, objects grew in size until several of them became what we call planets.

Panel #2

- Sunni is the Sun. It sits at the center of the solar system and is the source of light and heat. Because of its huge gravity, all of the objects in the solar system revolve (orbit) around it. In fact, that's why it's called the solar system: the Latin name for the Sun is *Sol*.
- The Sun formed the same way the planets did, by objects combining and also by it attracting a lot of the gas that was in the early solar system. The difference between the Sun and the planets is that the Sun became so huge that the temperature at its core (where all its energy comes from) grew to millions of degrees.

Panel #4

- Rocksanne = Mercury; Spark = Venus. Mercury is the planet closest to the Sun, and Venus is the second closest.

Panel #5

- Moonie = the Moon; Tara = Earth. (NOTE: Our planet's name is just "Earth," not "the Earth.") We chose Tara as the name for our character because the Latin name for Earth is *Terra*.

Panel #6

- A combination of the Sun's gravity and Earth's speed keeps our planet in its orbit. If Earth weren't moving, it would quickly fall into the Sun. And if the Sun weren't pulling on us with its gravity all the time, we'd go shooting off into space in a straight line. Likewise, the Moon revolves around Earth because it's moving at a certain speed and Earth's gravity is pulling it toward us.

Happy Birthday to Me (p. 17)

Panel #1 (Title)

- In this episode, we talk a bit about the birth of Earth's Moon.
- In 1898, English astronomer George Howard Darwin was the first to propose a theory that explained our Moon. He mistakenly believed that the Moon spun off an Earth that was spinning really fast.
- Almost 50 years later, in 1946, Canadian geologist Reginald Aldworth Daly proposed the first theory that a giant impact had created the Moon.

Panel #4

- Our Moon is younger than most bodies in the solar system. Current theories place its formation 20 million to 100 million years after the planets formed. That falls in the Hadean eon, Earth's first geologic eon, which lasted from 4.6 billion years ago to 4 billion years ago.

Panel #6

- We didn't make this name up. Theia is the name astronomers gave to the planet-sized body whose collision with Earth formed the Moon. Astronomers think Theia was about the same size as Mars (about 3,700 miles in diameter) and that it originally was in a spot in Earth's orbit, either a little bit in front of our planet or a little bit behind it.
- The name for this body comes from Greek mythology. Theia was a Titan and sister of Cronus (whose Roman name was Saturn), the father of Zeus. She was the mother of Selene (goddess of the Moon), Helios (god of the Sun), and Eos (goddess of the Dawn).

Panels #7-8

- These panels shows Theia striking Earth head on. Scientists who first proposed a collision between the two bodies originally thought Theia may have hit our planet at a steeper angle. Recently, though, the head-on impact seems more likely based on analysis of Moon rocks brought back to Earth by three teams of Apollo astronauts.

Panels #9-11

- The collision between Earth and Theia didn't knock off a Moon-sized chunk that went into orbit around our planet. Instead, the collision created trillions of small objects that formed a ring around Earth. Eventually, gravity pulled the pieces together.

One Moon to Rule Them All (p. 25)

Panel #1 (Title)

- In this episode, we show that, for a short time, Earth originally had two moons.

Panel #2

- As we learned in the previous episode of *Outer Space Pals*, the Moon formed after Theia, a body the size of Mars, crashed into Earth. Recent theories, however, say that not one, but two moons formed. The small one was about 38 percent as large as the big one.

Panel #3

- The small moon formed in a place where its gravity balanced the gravity of Earth. A small body (in this case, the small moon) could theoretically stay there forever.

Panel #4

- But our case was special because of the large moon. As it pulled away from Earth (really slowly), it changed the gravitational balance of the system and eventually the two moons merged. In fact, both moons were moving away from Earth, but the large one (because of its greater mass) would have moved away faster.

Panel #5

- Because both original moons were part of the Earth system, they orbited our planet in the same direction and they moved fairly slowly. The speed they were going when they hit, then, would have been a lot slower than when Theia struck Earth.

Panel #6

- One question lunar scientists have had since they first saw the farside of the Moon (the first photographs were sent back to Earth by the Soviet spacecraft Luna 3 in 1959) was why the two hemispheres look different. This new theory that proposes two original moons goes a long way to explaining that difference.

Panels #7-8

- Tara seems confused. She believes, like many people, that because the Moon always keeps the same face toward Earth, it doesn't spin.

As the World Turns (p. 29)

Panel #1 (Title)

- In this episode, we show that the Moon does spin.

Panel #2

- If you're like Tara — that is, if you think the Moon doesn't spin as it travels around Earth — you're not alone. Many people in the U.S. think the same thing.

Panel #5

- We start off knowing one thing for certain: The Moon always keeps the same face toward Earth.

Panel #6

- The diagram in this panel shows what we just said in the last sentence.
- It's easy to show how this works. Put a chair in the middle of a room. It's a better demonstration if someone is sitting in it, but an empty chair will show you how this works before you show it to someone else. That chair will represent Earth, and you will be the Moon. Stand a few feet away from it, and face it. Also notice which wall in the room you're facing. Next, orbit halfway around the chair, always keeping your front side toward it, and stop. A quick glance at the room will show that you're now facing the opposite wall. Aha! For this to happen you must have rotated one-half spin. Continue around to your starting point, and you'll see that as you orbited once, you also rotated once. (You'll find a version of this activity on p. 67.)

Panel #7

- To get across the point that the Moon is spinning, our drawing may make it look like our satellite is rotating really fast. It's not. It takes the Moon 27 days 19 hours and 18 minutes to spin just once.

Panel #8

- As Sunni is saying, the Moon also takes 27 days 19 hours and 18 minutes to revolve (orbit) around Earth once.

Faces of Day and Night (p. 33)

Panel #1 (Title)

- In this episode, we start to talk about the Moon's phases.

Panel #3

- The only thing that determines the Moon's phase is the angle between the Sun, Earth, and the Moon. If the Sun and the Moon are on the same side of Earth, the angle between them (you could call it the Sun-Earth-Moon angle) is 0°, and the Moon's phase is New. If the Sun and the Moon are on opposite sides of Earth, the Sun-Earth-Moon angle is 180°, and the Moon is Full. When this angle is 90° or 270°, the Moon's phase is First Quarter or Last Quarter, respectively.

Panel #4

- Moonie's remark, "Except I go around backward," refers to the fact that, if you could look down on our solar system, you'd see the Moon revolving in a counterclockwise direction around Earth.

Panel #5

- This panel is not to scale, but saying that hardly does it justice. The Sun is nearly 400 times farther from Earth than the Moon is. (The exact number is 389 times.) So, Sunni would be way, WAY out of the left side of the panel if even just the distances were to scale.

More Than a Pretty Face (p.38)

Panel #1 (Title)

- In this episode, we continue our discussion of the Moon's phases.

Panel #2

- Refer to the clock face in Episode #5 (p. 33). When the Moon's position is at 3 o'clock, it lies in the opposite direction in our sky from the Sun, which is at 9 o'clock. On nights when this happens, the Moon rises at sunset, is highest at midnight, and sets at sunrise. This is Full Moon.

Panel #3

- Remember, the Moon goes around our clock face-backward. So, if it's Full Moon (at the 3 o'clock position), it will be Last Quarter when it's at the 12 on our clock. Half a clock trip later, the Moon is at 6 o'clock. We call this phase First Quarter.

Panel #4

- At clock position 4:30, we call the Moon's phase a waxing gibbous; at 1:30, it is a waning gibbous.
- "Gibbous" comes from a Latin word that means "humped" and refers to the Moon's shape.
- "Waxing" means the Moon's lit face is growing, while "waning" means it's shrinking. The Moon is waxing between New Moon and Full Moon. The Moon is waning between Full Moon and New Moon.

Panel #5

- Because the Sun is the source of light, it sees everything it lights up in a full phase.

Panel #6

- The two thinnest crescent Moons are near, but not at, the 9 o'clock hour (which would be New Moon).
- Tara says her favorites are the "fingernail" Moons. She's referring to the thin crescents. There are two of these during each lunar month. Most people see one of these after New Moon, low in the western sky once the Sun has set. Some early risers see a thin crescent Moon low in the east before sunrise.

Panels #7-8

- One of the coolest things about the Moon is that often when its phase is a thin crescent, Earth reflects light on the dark part, making it visible. We call this reflected sunlight "earthshine." People sometimes call it "the old Moon in the New Moon's arms."

Mirror, Mirror (p. 49)

Panel #1 (Title)

- In this episode, we talk about how much light the Moon and the planets reflect.

Panel #2

- The color of an object is the main factor that determines how much light it reflects. To a lesser extent, how irregular a surface is can factor into how much light bounces off. So, a smooth surface of a color will reflect more light than a rough surface of the same color.

Panel #3

- As our characters are saying, how bright a planet (or moon or asteroid or comet, etc.) looks depends on three things: how much light it reflects, how close it is to the Sun and Earth, and how big it is.

Panel #4

- This is a great thought question. It eliminates the size and distance factors. So, it really changes the question from, "Which planet is brightest?" to "Which planet reflects the greatest percentage of light falling on it?"

Panel #5

- This panel answers that question.
- Venus (Spark) reflects a whopping 65 percent of the light that falls on it, mainly because of the planet's thick layer of clouds.
- Jupiter (Jules) is next, but not because of its size. It also has many bright clouds, although some of them are darker than the ones covering Venus. Jupiter reflects 52 percent of the Sun's light that hits it.
- Uranus (Urania) comes in third, reflecting 51 percent of the light striking it back into space.
- Saturn (Saffron) claims the fourth spot at 47 percent, and Neptune (Noah) takes fifth place with a reflectivity of 41 percent.
- Earth (Tara) reflects 37 percent of the sunlight falling on it, mainly because of the bright clouds that give us our weather. But clouds don't cover our whole planet, and the water and ground that isn't covered by clouds don't reflect as much light back into space.
- Then there's a real drop to reddish Mars (Rusty), in seventh place, which reflects only 15 percent of the light hitting it.
- Mercury (Rocksanne) is the least reflective planet, absorbing 90 percent of the Sun's light and bouncing off only 10 percent. So, remember, Mercury appears as bright as it does because it's so close to the Sun.
- Finally, our Moon is only a slightly better mirror than Mercury. It reflects 12 percent of the Sun's light.

Panel #6

- It's really amazing how unreflective the Moon's surface is. A pine forest seen from above looks pretty dark. And here's something else to think about: Scientists who measure how much light things reflect tell us there's one other surface that reflects the same amount of light as the Moon: an aged asphalt street that's been used for some time. (A brand-new asphalt street is so black that it only reflects 5 percent of the light hitting it.)

- Just so you know, scientists who study how much light (or other types of radiation) a celestial body reflects use the word *albedo*. Albedo equals reflectance, so it's OK to say, "That's how much light the Moon reflects," rather than "That's the Moon's albedo."

Wake Up and Smell the Planet (p. 58)

Panel #1 (Title)

- In this episode, we discuss how smells move from one place to another.

Panels #2-7

- In humans and animals, certain molecules (called odors) interact with sensors in the nose. These odors move through the air. But there's no air in space (it's a vacuum), so there's no way for odors to reach our noses. We couldn't take even one breath in space!

Panel #8

- Of all the planets, only Mercury has no atmosphere. The Moon also has no atmosphere.

True Colors (p. 66)

Panel #1 (Title)

- In this episode, we'll learn a bit about the atmospheres of the planets.

Panel #2

- When we say the Sun is gas, that's the easy way to talk about what it's made of. Three-quarters of it is hydrogen and one-quarter is helium. (And there's a tiny bit of about 50 other elements in the Sun.) Both of those elements are gases on Earth, so astronomers think they act the same on the Sun.

Panel #3

- Mercury and the Moon have no atmosphere. One thing a planet's atmosphere does is act like a shield against meteors. In Earth's case, most meteors burn up because of friction with our air. Only the biggest ones land, and only the biggest of those make craters. But Mercury and the Moon have no air, so their surfaces are covered with craters big and small.

Panels #4-6

- Earth is part of a colorful solar system. And Noah and Rusty are asking some great questions about the reasons.

Panel #7

- How much air a planet can hold depends on only one thing: its mass. Mass is a measure of how much material something contains. The more mass something has, the stronger its gravity will be. Aha! That's why bigger planets have more air, and it's also why they can hold onto lighter gases.

Panel #8

- Earth also has more cloud-making stuff in its atmosphere than Mars does, mainly water in the form of ice crystals. We do see clouds on Mars, but they are much less dense than ours, so they usually don't last long.

Panel #9

- Water ice isn't the only material that can form clouds. The big outer planets have little water in their atmospheres, but they're covered in clouds made of methane, ammonia, and other compounds. When sunlight hits those gases, the gas absorbs certain colors in the sunlight and reflects what's left. For example, methane in Neptune's atmosphere absorbs the red, orange, and yellow colors in sunlight. What's mainly left is blue, which it reflects, so that's the color we see.

Panel #10

- Astronomers have observed large spots on both Neptune and Jupiter. Neptune's dark spots come and go, but we've been watching Jupiter's Great Red Spot for more than 350 years. Oh, and it's huge! The Great Red Spot is about as large as three Earths. All spots like these on planets are storms that move (spin) like hurricanes on Earth.

Shadow Play (p. 79)

Panel #1 (Title)

- In this episode, we'll start to learn about shadows that fall on planets and moons.

Panel #2-3

- If there's a shadow, there

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Curiosity's Martian Selfie, Aug. 5, 2015.

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must be something giving off light making the shadow. The brightest object in the space around us is the Sun, so it's usually the object making shadows. The Moon can cast shadows, too, when it's bright.

- What we call a "shadow," then, is really the dark area where an object blocks light from reaching another object. Shadows always take on the shape of the object that's blocking the light. So, the shadow of a round planet or moon will be round.

Panel #4-5

- For a moon to cast its shadow on a planet, it has to be large enough — and close enough to the planet — that the shadow actually reaches the planet. Several of the big moons of Jupiter, Saturn, Uranus, and Neptune are large enough for that to happen, but the small moons of those planets (and there are quite a few of them) aren't big enough.
- Mars' two moons are too small to cast a shadow on that planet. And Mercury and Venus have no moons, so no shadows fall on those worlds, either.

Panels #7-8

- Moonie points out something important about his shadow: Sometimes it reaches Tara, and at other times, it doesn't.

Deep Dark Secret (p. 85)

Panel #1 (Title)

- This episode is about eclipses.

Panels #2-3

- The Moon has two types of shadows because the Sun is a big object. It's not a single point of light like the stars at night. So, for example, the bottom of the Moon blocks the light from the top of the Sun. That creates a shadow. But because some light from the bottom of the Sun passes by the Moon without being blocked, that light falls into part of the shadow. This causes the shadow to be lighter.
- Astronomers call the outer shadow of the Moon the penumbra. If you're under the penumbra during a solar eclipse, you will see a partial eclipse. That is, only part of the Sun will be covered by the Moon.
- **PLEASE NOTE:** The Sun is so bright that it's dangerous to look at it. So, anytime the Moon covers only part of the Sun, you MUST wear approved solar viewing glasses.

Panel #4

- During total eclipses of the Sun, there will be a spot on Earth where the Moon covers the Sun's whole face.
- Astronomers call the inner shadow of the Moon the umbra. If you're under the umbra during a solar eclipse, you will see a total eclipse. That is, all of the Sun will be covered by the Moon.

Panel #5

- When you look at the totally eclipsed Sun, you'll see our star's thin outer atmosphere. Astronomers call it the corona. *Corona* is the Latin word for "crown."
- And here's something interesting. Many people think it gets completely dark during totality. But the corona actually puts out a lot of light. How much? As much as the Full Moon. That's right, the Full Moon and the Sun's corona shine with the same brightness. But you can't see the corona normally because the Sun's face outshines it by 1 million times.

The Great Beyond (p. 89)

Panel #1 (Title)

- In this episode — our last — we investigate other kinds of celestial objects.

Panel #3

- That's a lot of moons! And they're pretty much all in the outer solar system. Of the eight planets, the first four have only three moons: Mercury and Venus have zero, Earth has one, and Mars has two. But then we reach Jupiter. It has a whopping 79 moons! And that's as of right now — more could be discovered. Saturn has 62, Uranus has 27, and Neptune has 14. Even Pluto, which isn't a planet anymore, has five.

Panel #4

- Asteroids, also called minor planets, are small objects made mostly of rock, but some also contain a little metal. There are several million of them, most of which orbit the Sun in a region — called the asteroid belt — between Mars and Jupiter. Of those millions of objects, 28 asteroids have diameters of 124 miles (200 kilometers) or larger. As a reference point, astronomers think an asteroid only 6 miles (9.7 km) across hit Earth 66 million years ago and wiped out the dinosaurs.

Panel #5

- To learn a lot more about comets, see the story on p. 46–47.

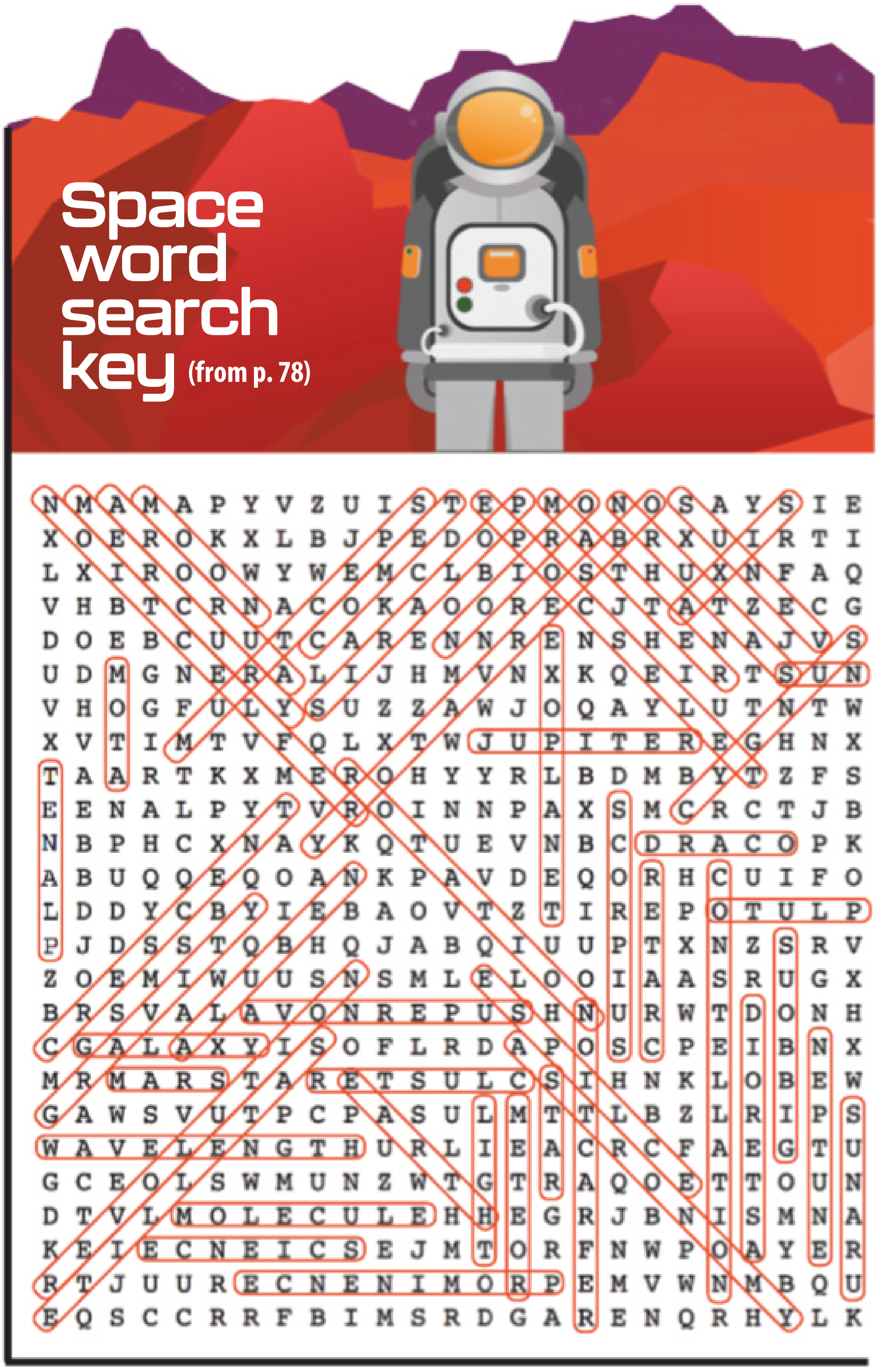
Panel #6

- Stars are far away, much farther than even the most distant comets. The closest star — its name is Alpha Centauri — is about 270,000 times as far away from us as the Sun. Wow!

Panel #7

- We hope you liked *Outer Space Pals*. We sure had a lot of fun putting it together.

Space word search key (from p. 78)



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